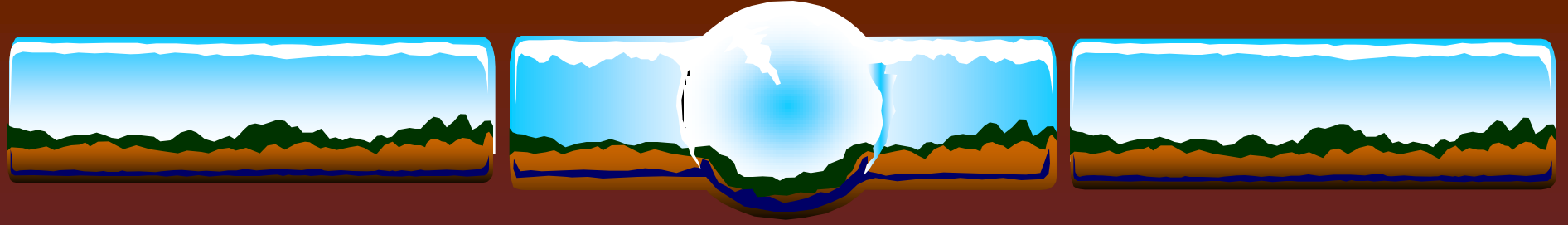


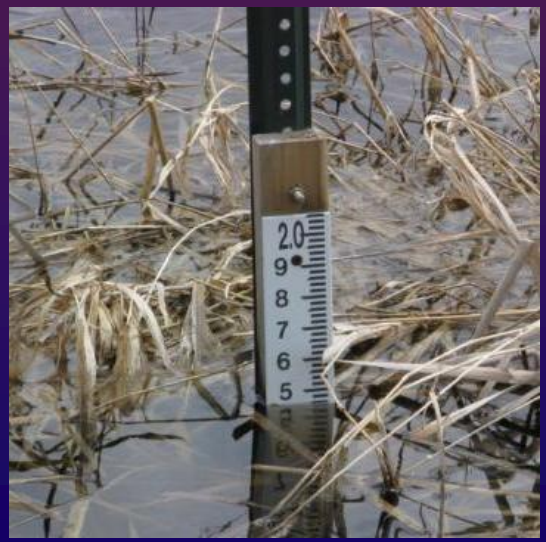
Monitoring Wetland Hydrology

BWSR Academy
October 26, 2011

Eric Mohring
eric.mohring@state.mn.us
651-297-7360

Monitoring Wetland Hydrology

- What is Monitoring?
- Why Monitor?
- What's the question?



What is Monitoring?

Evaluation over a period of time of one or more of :

Indicators	
Ground Water levels:	• saturation depths • piezometric “head” or potential
Surface Water levels:	• ponding • flooding
Water Budget Inputs & Outputs	• precipitation • surface water inflow & outflow • ground water inflow & outflow

Why Monitor Hydrology?

- "Beyond delineation"
- Verify site wetness
  (depth, duration, frequency)
- Verify delineations, resolve disputes
- Determine water movement
- Restoration/replacement success
- Wetland creation potential
- Functional assessments
- Calcareous fen determination

Monitoring Wetland Hydrology

- VERY Important to agree on the **QUESTION** before monitoring.

Wetland determination

- Is wetland hydrology present?
- What are the wetland types present?

Wetland delineation & boundary determination

- Is wetland hydrology present?
- Where is the wetland/non-wetland hydrology boundary?

Functional assessment: depth, duration, frequency, timing of wetness.

- Depth of water table?
- Duration, frequency of saturation?
- Seasonality?

Functional assessment: Determine Inputs & outputs

- How does wetland interact with ground water (recharge or discharge)?
- How does water flow into or out of the wetland?

Potential for wetland restoration or creation

- What is the lateral effect of a drain or ditch?
- What depth is the water table?
- What are the hydrologic inputs and outputs?

Evaluate hydrologic alteration

- What is the lateral effect of a drain or ditch?
- Has a wetland been effectively drained? Or partially drained?
- How well is drain tile functioning?

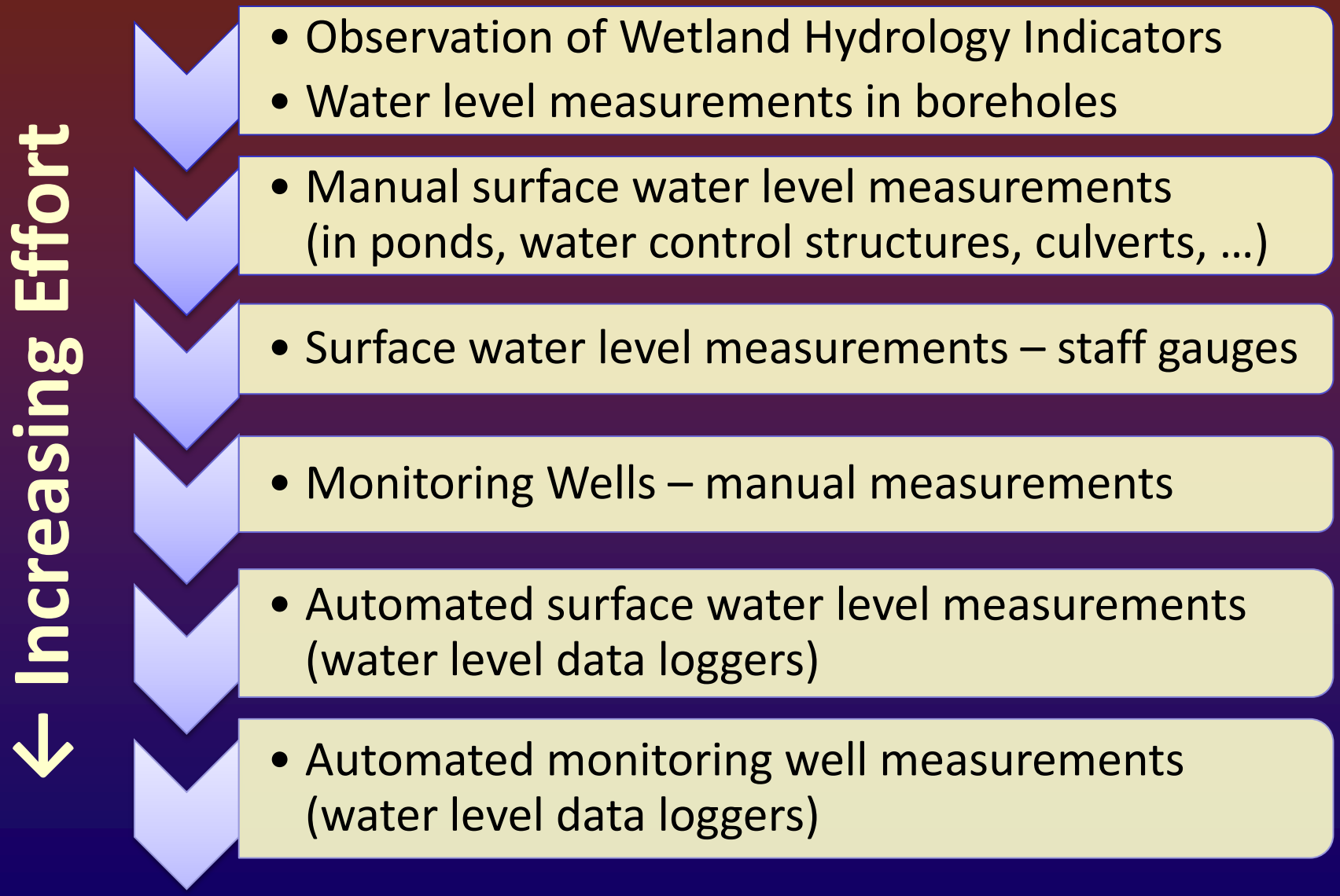
Success of wetland restoration or replacement

- How much has water table depth changed since drain was removed?
- Has wetland hydrology been restored?
- Is restored hydrology adequate to support planned plant communities

Calcareous fen ?

- What is the direction of ground water flow?
- Does ground water discharge to the wetland?
- If so, is the discharging ground water alkaline?

“Levels” of Hydrologic Monitoring



Wetland Hydrology Indicators

Regional Supplements

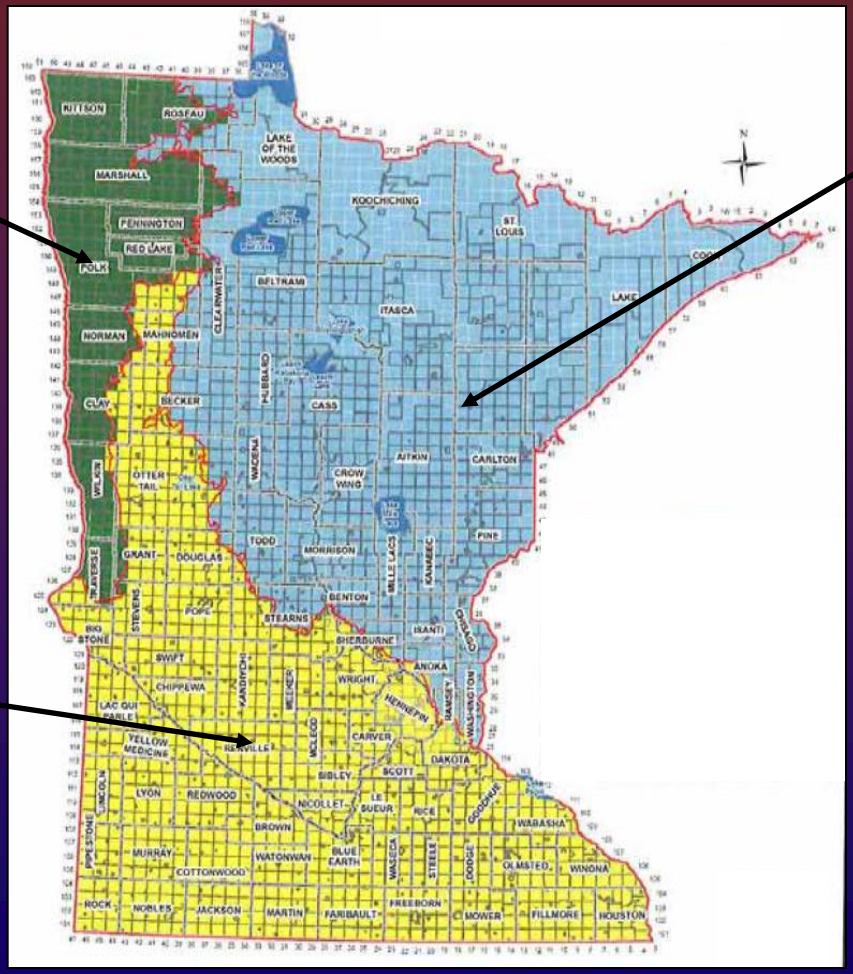


Table 9. Wetland hydrology indicators for the Midwest Region.

Indicator	Category	
	Primary	Secondary
Group A – Observation of Surface Water or Saturated Soils		
A1 – Surface water	X	
A2 – High water table	X	
A3 – Saturation	X	
Group B – Evidence of Recent Inundation		
B1 – Water marks	X	
B2 – Sediment deposits	X	
B3 – Drift deposits	X	
B4 – Algal mat or crust	X	
B5 – Iron deposits	X	
B7 – Inundation visible on aerial imagery	X	
B8 – Sparsely vegetated concave surface	X	
B9 – Water-stained leaves	X	
B13 – Aquatic fauna	X	
B14 – True aquatic plants	X	
B6 – Surface soil cracks		X
B10 – Drainage patterns		X
Group C – Evidence of Current or Recent Soil Saturation		
C1 – Hydrogen sulfide odor	X	
C3 – Oxidized rhizospheres along living roots	X	
C4 – Presence of reduced iron	X	
C6 – Recent iron reduction in tilled soils	X	
C7 – Thin muck surface	X	
C2 – Dry-season water table		X
C8 – Crayfish burrows		X
C9 – Saturation visible on aerial imagery		X
Group D – Evidence from Other Site Conditions or Data		
D9 – Gauge or well data	X	
D1 – Stunted or stressed plants		X
D2 – Geomorphic position		X
D5 – FAC-neutral test		X

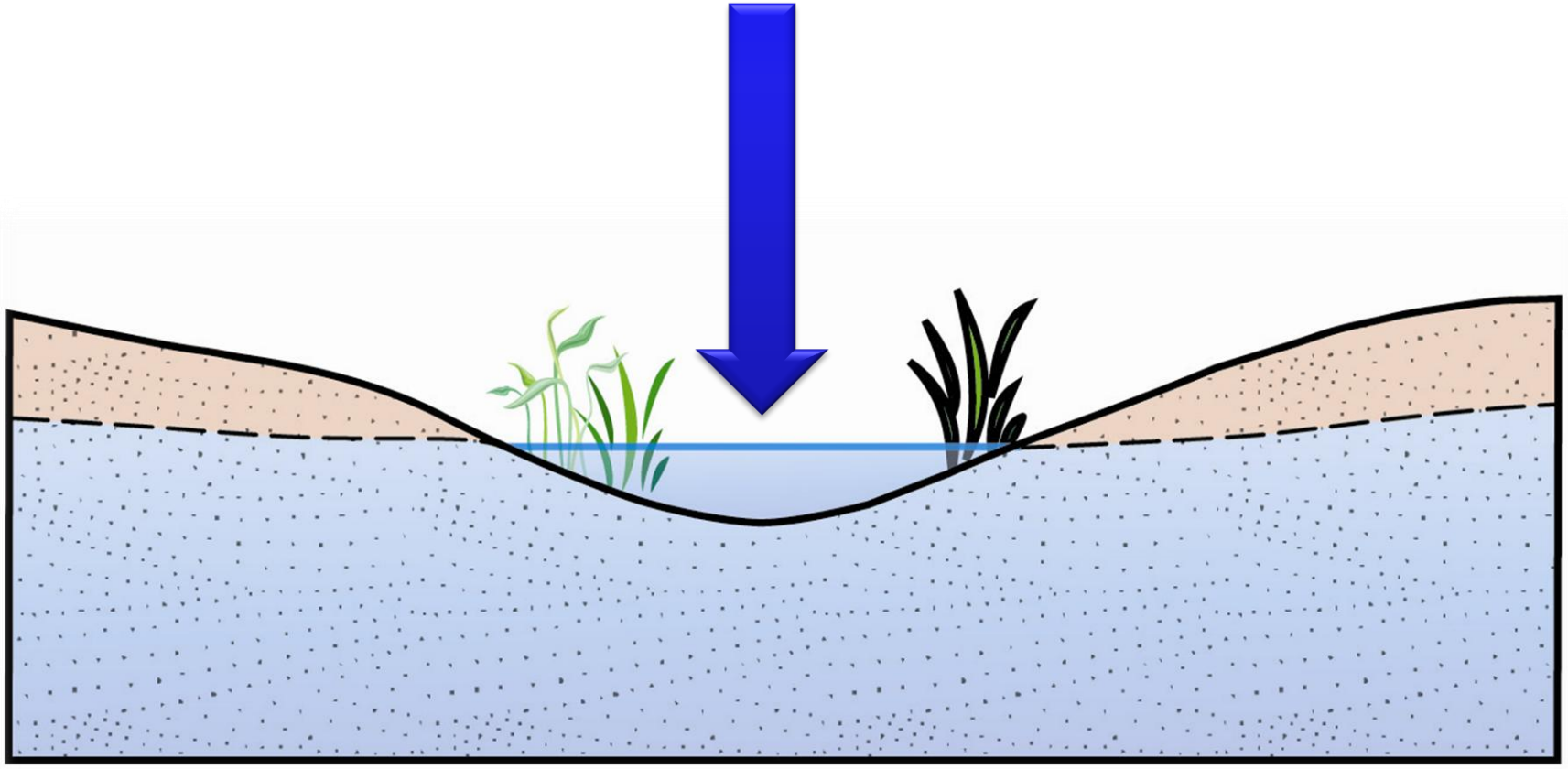
Wetland Hydrology Indicators

- Indicators in the 87 Manual are gone (10 indicators).
- Replaced by Chapter 4 of the regional supplements (25 to 29 indicators).

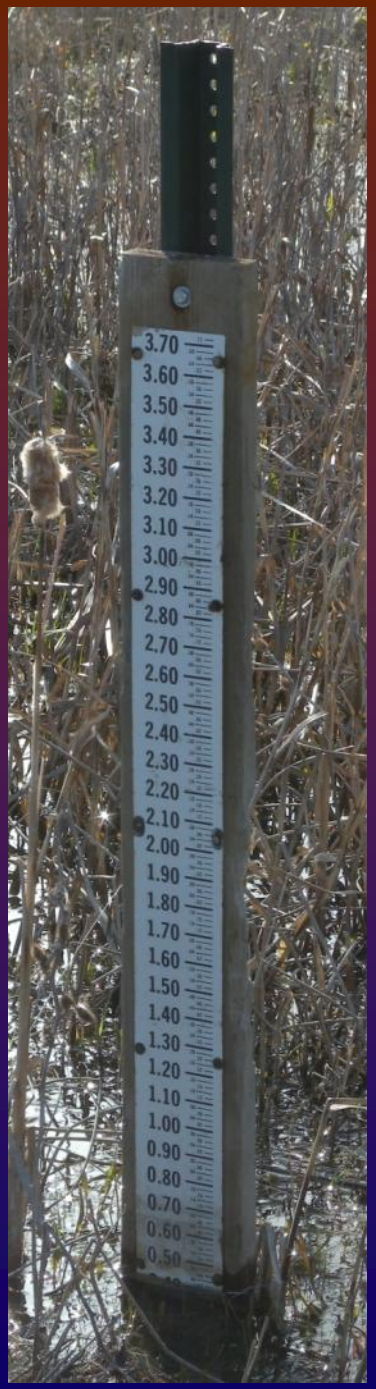
Water level measurements in boreholes

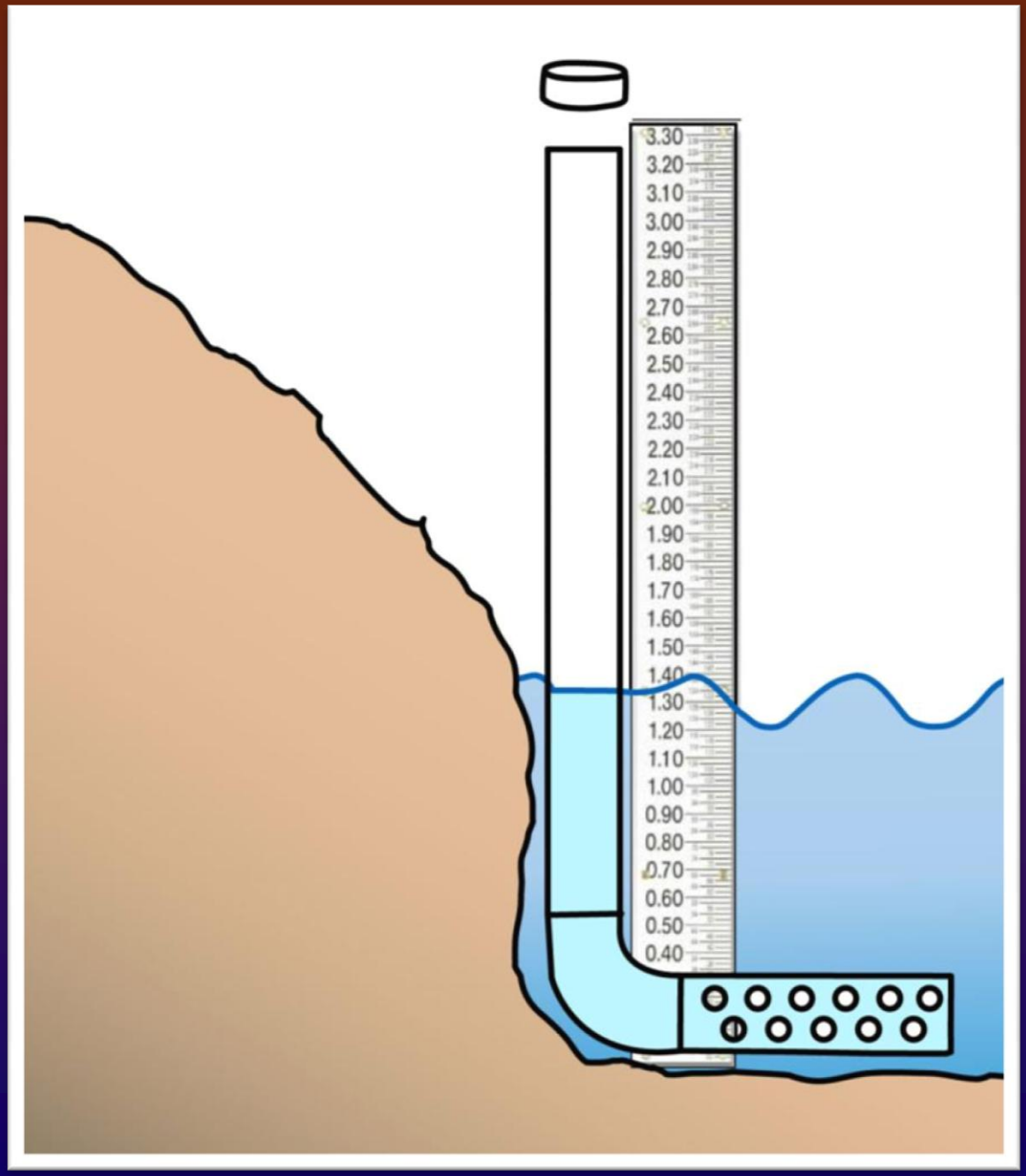
- Allow time to equilibrate
- Watch out for smearing

Surface Water Levels



Staff Gauges



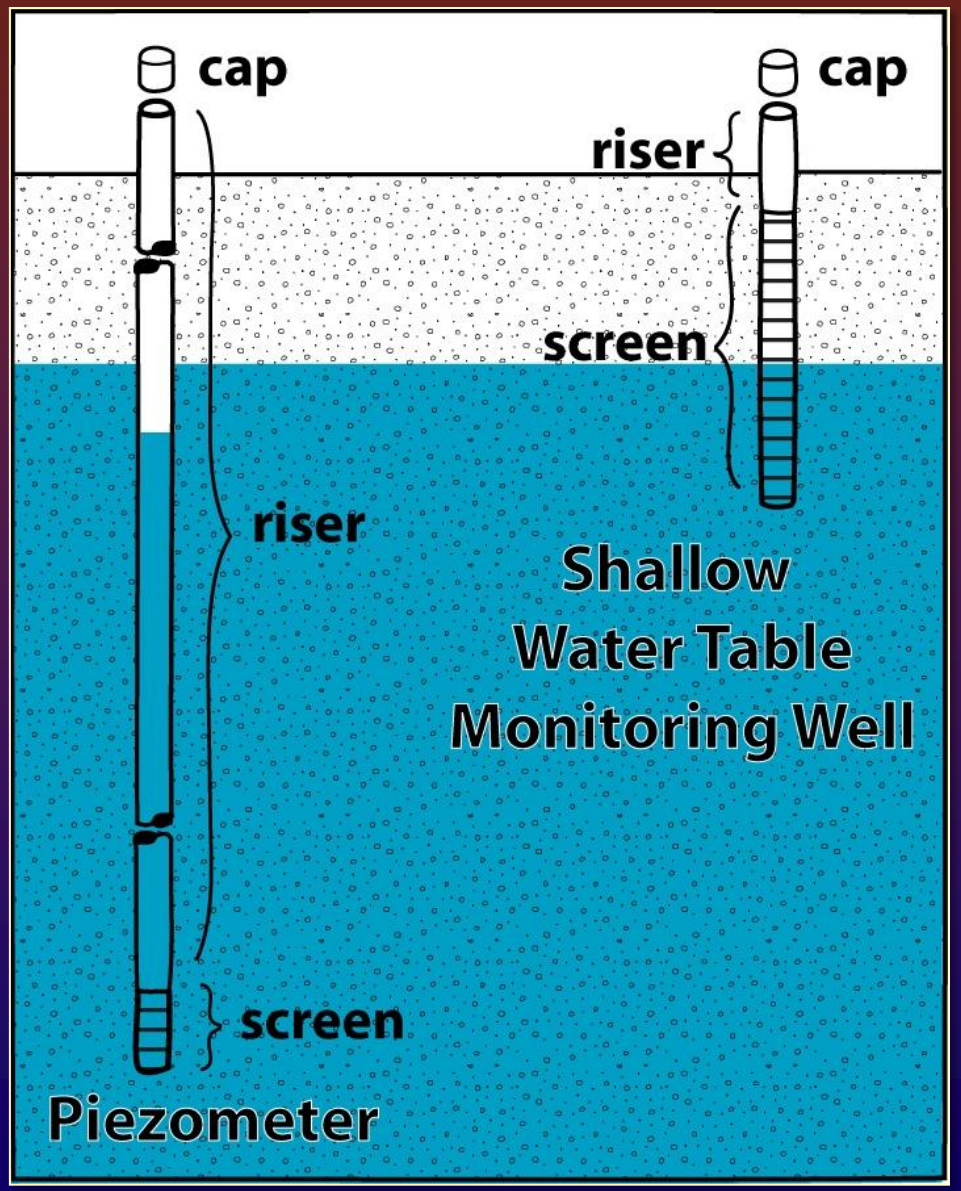


Stilling Well

Water Control Structure

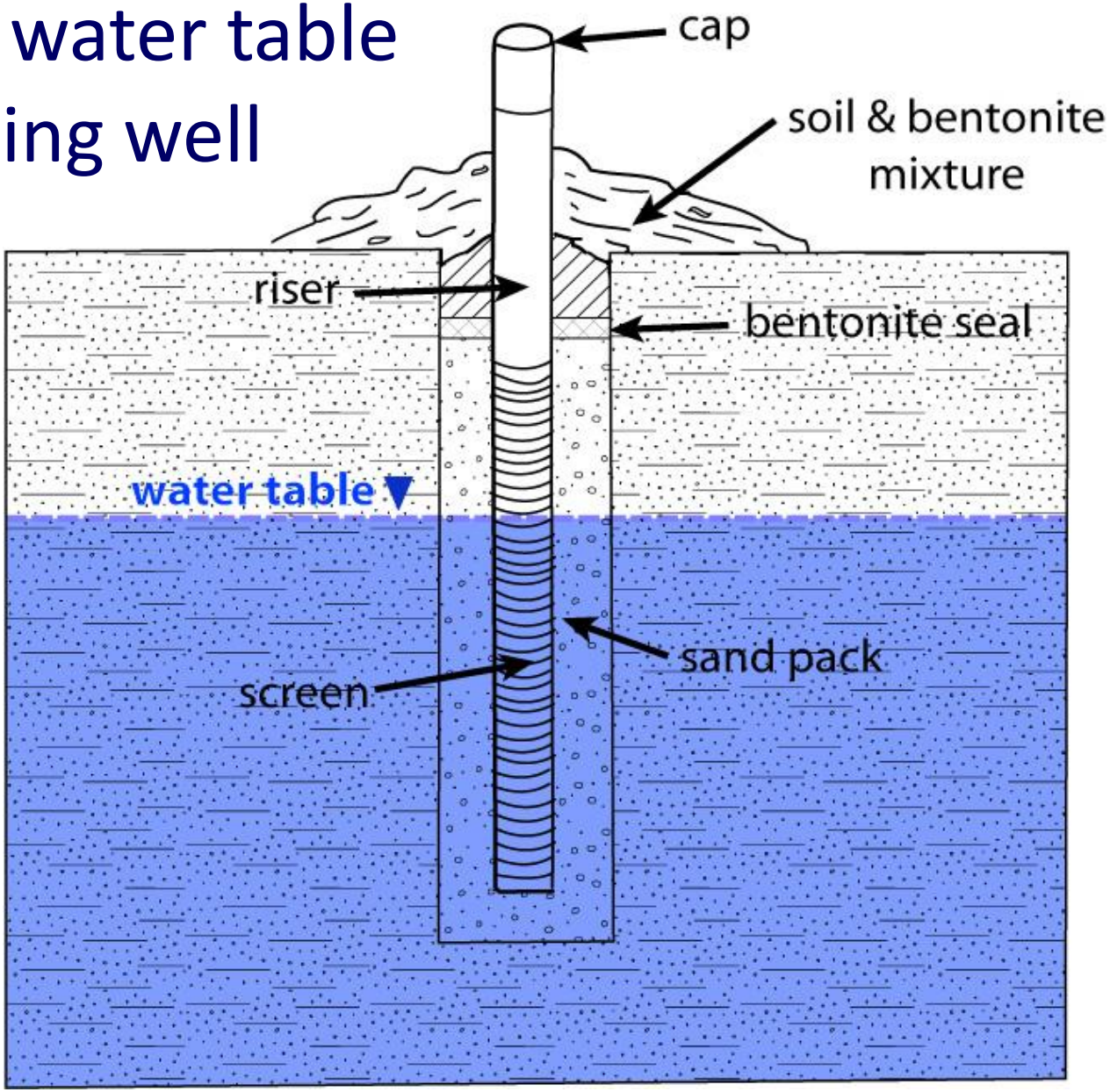
Measuring Ground Water Levels

- Water Table Monitoring Wells
- Piezometers

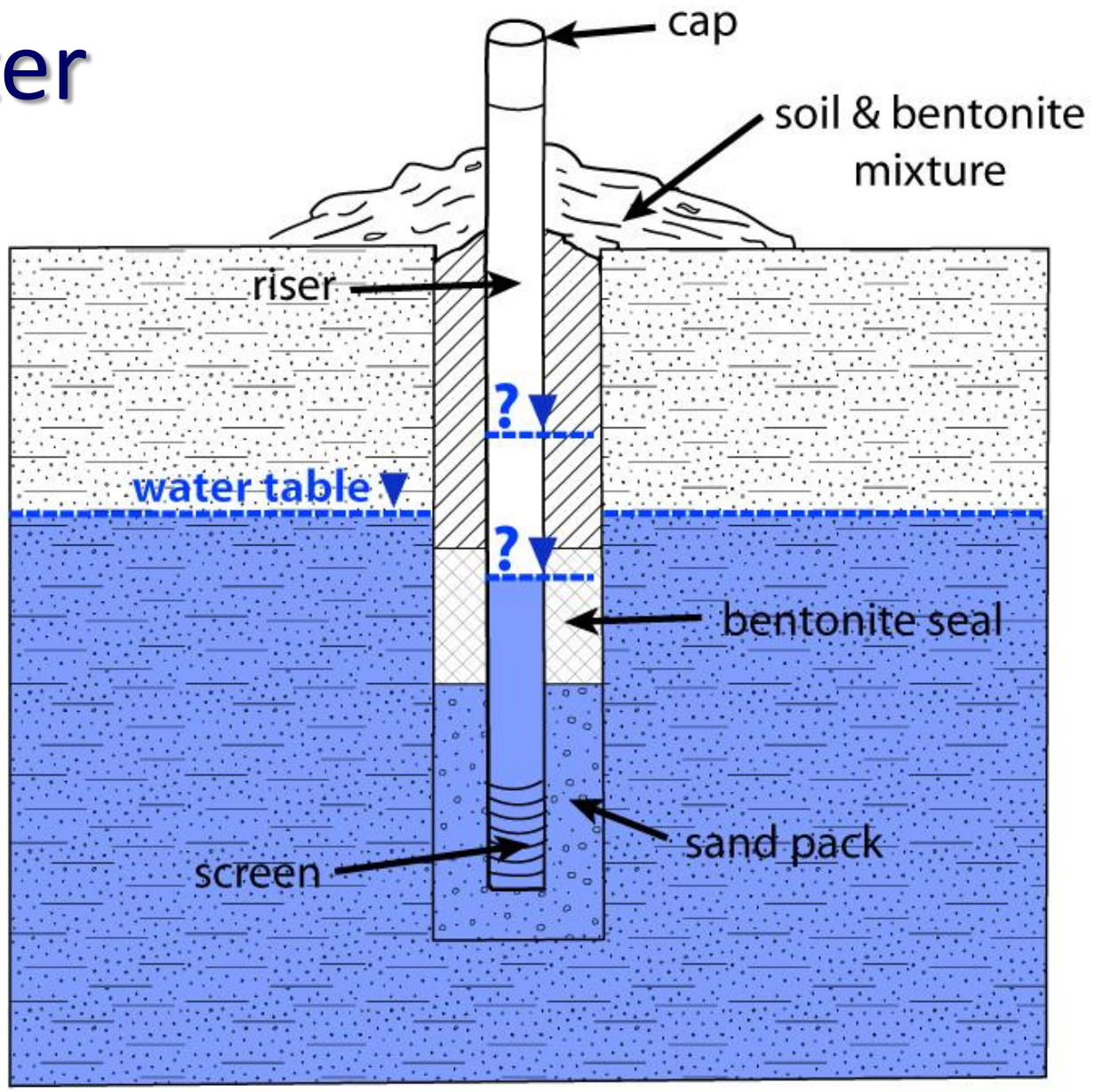


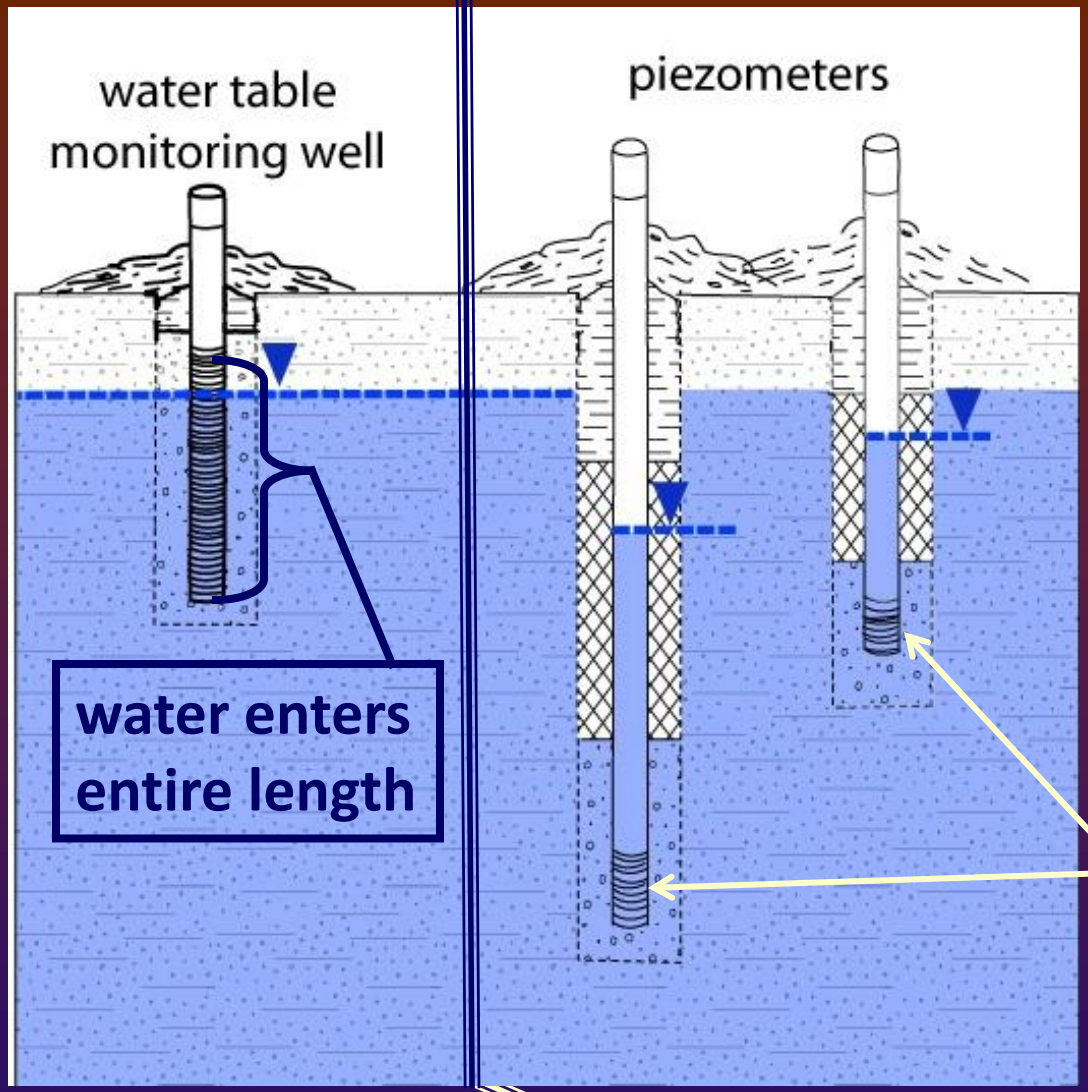
Terminology & Semantics

Shallow water table monitoring well



Piezometer


cap
soil & bentonite mixture
riser
?
water table
?
bentonite seal
sand pack
screen



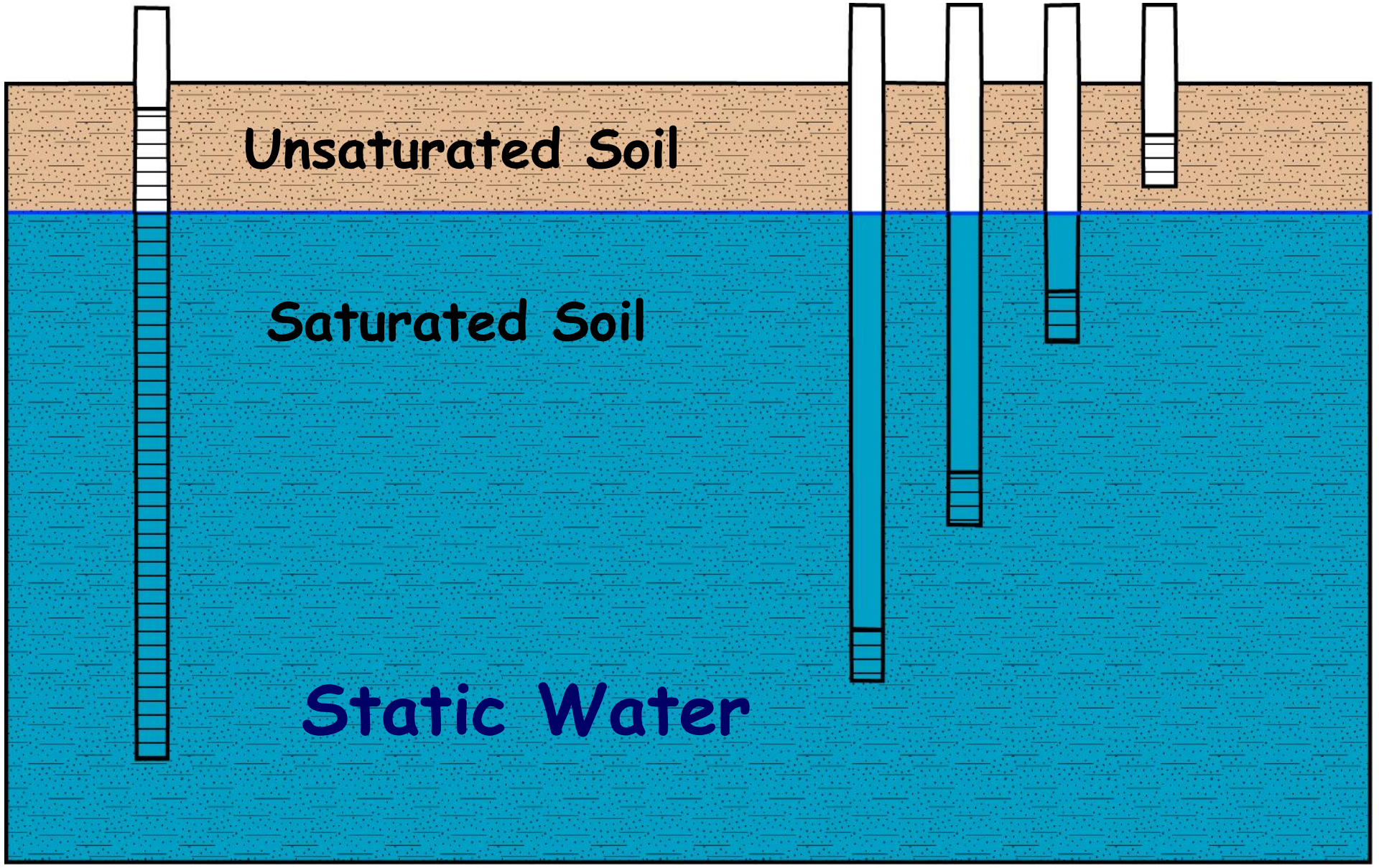
Piezometers:

- do not (necessarily) measure saturation levels
- monitor head (pressure) differences
- water movement

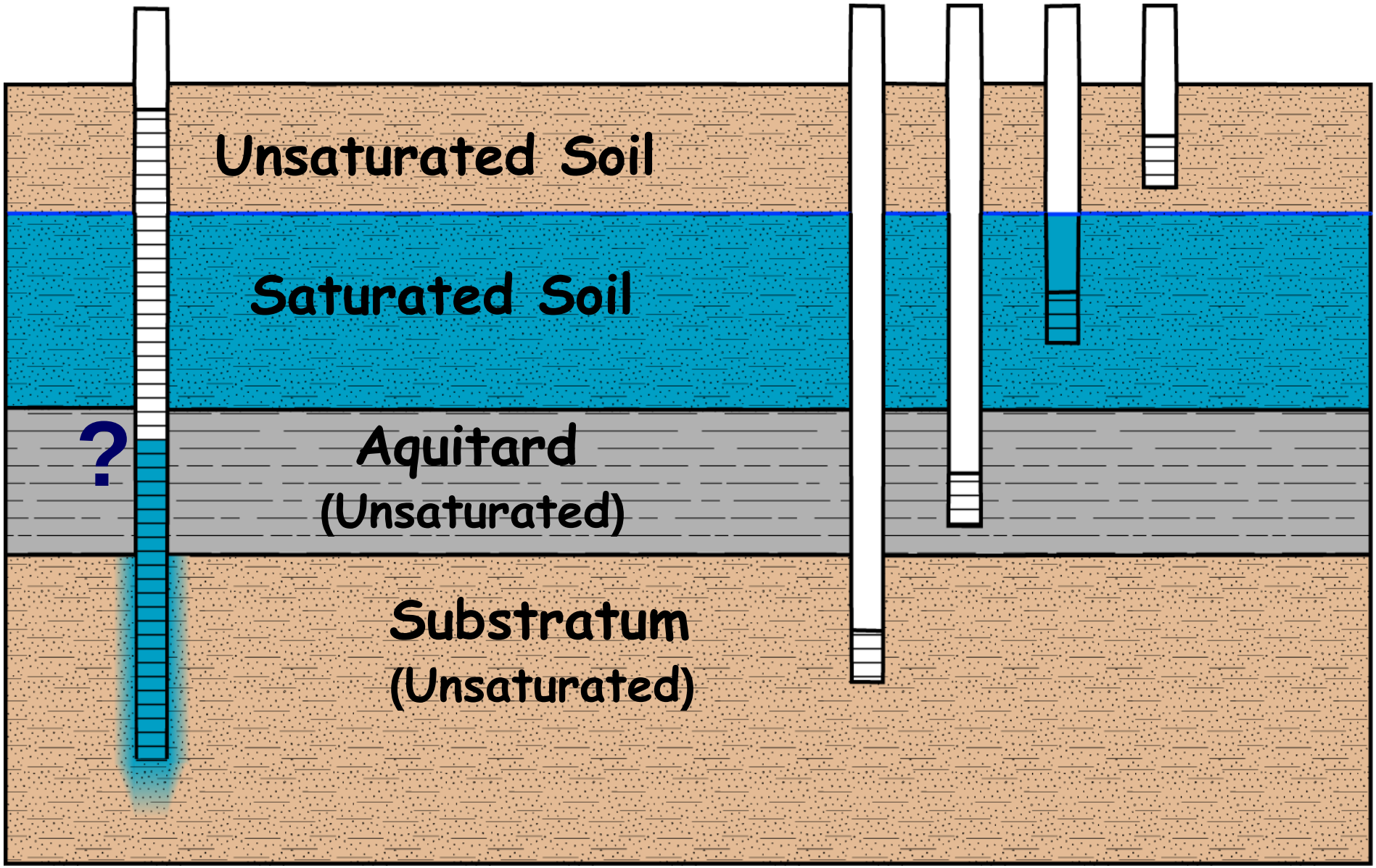
Water table monitoring wells:

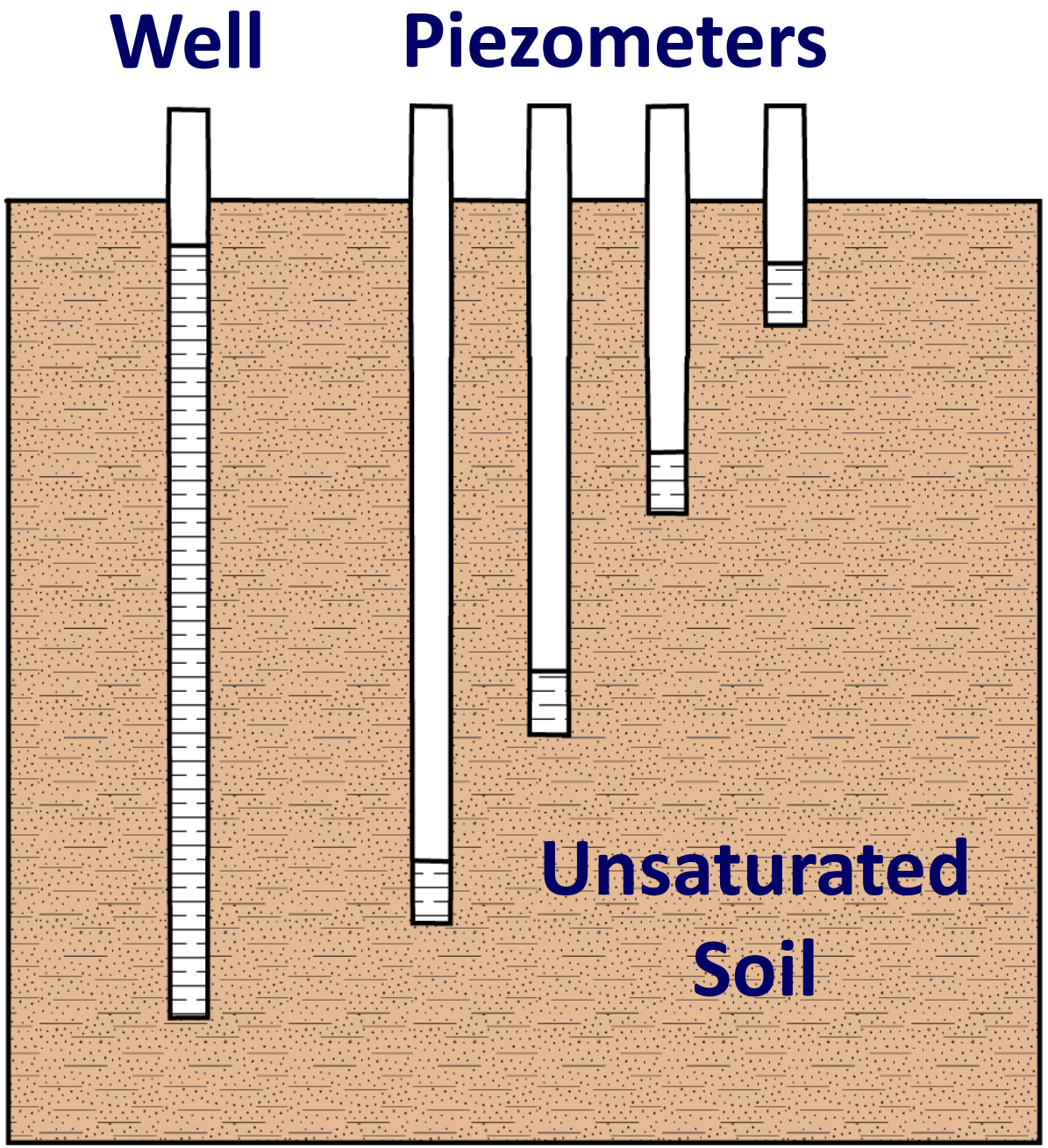
- measure saturation

Well & Piezometer Comparison

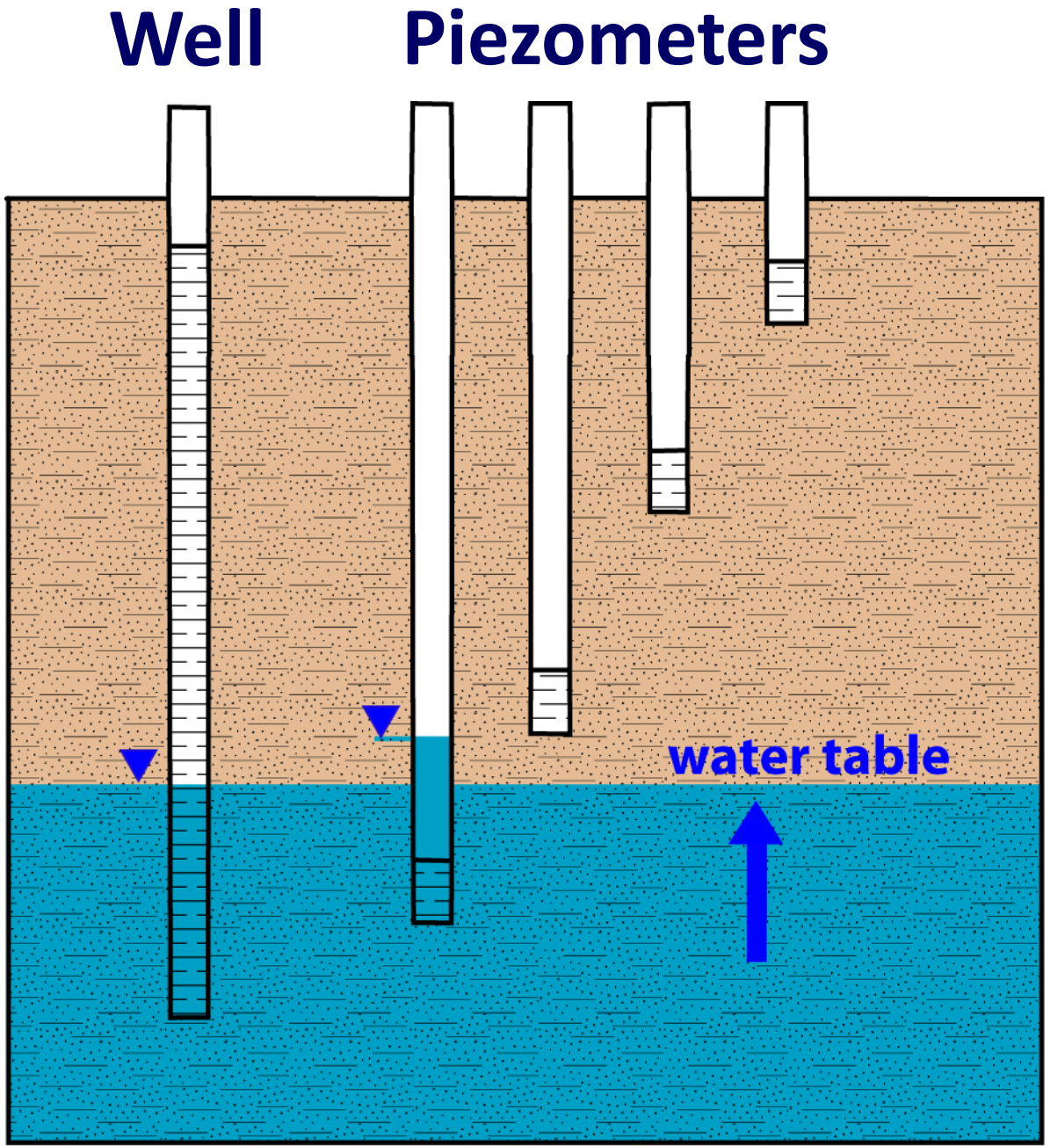


Well & Piezometer Comparison

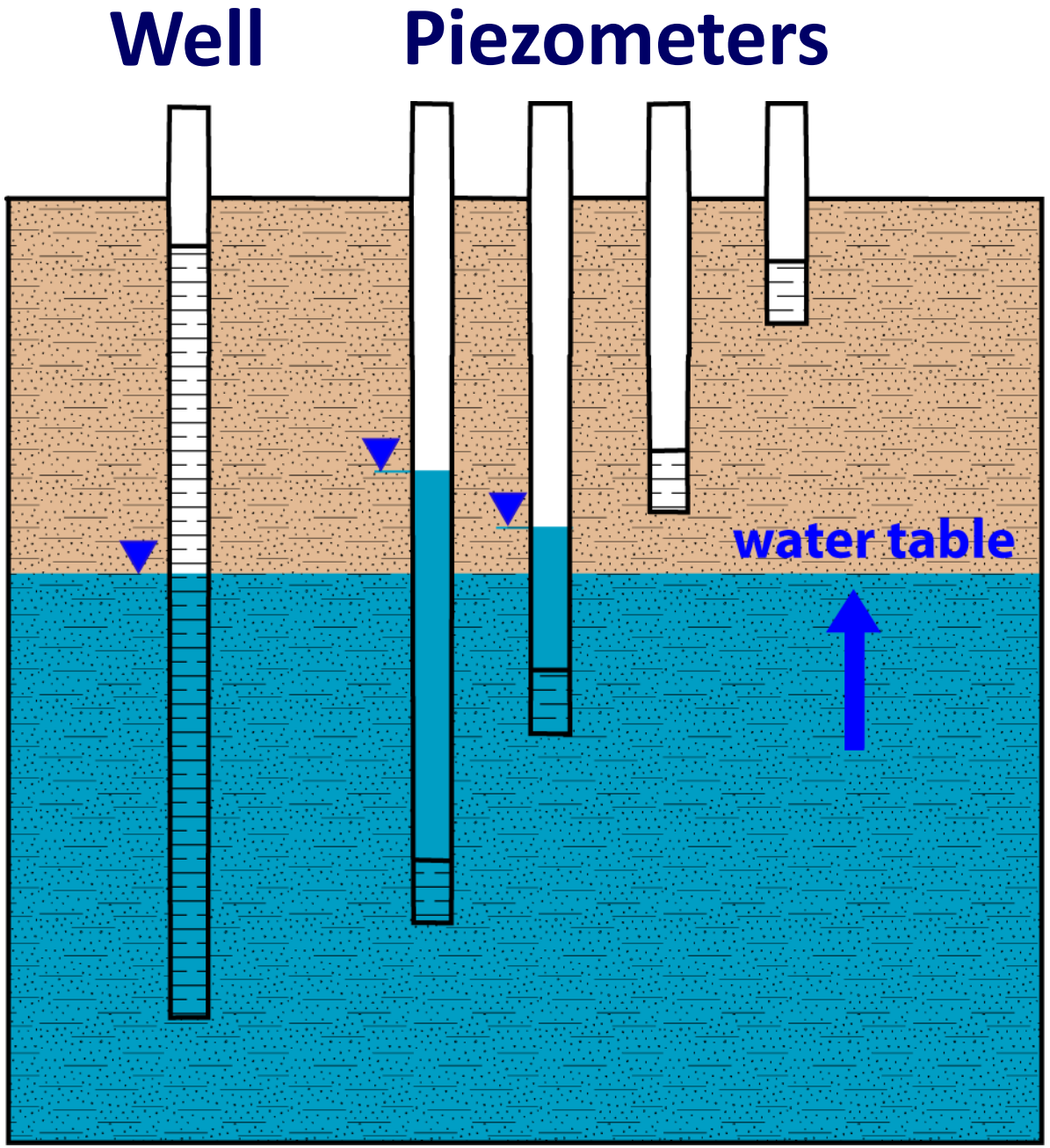



Well
Piezometers
Unsaturated
Soil

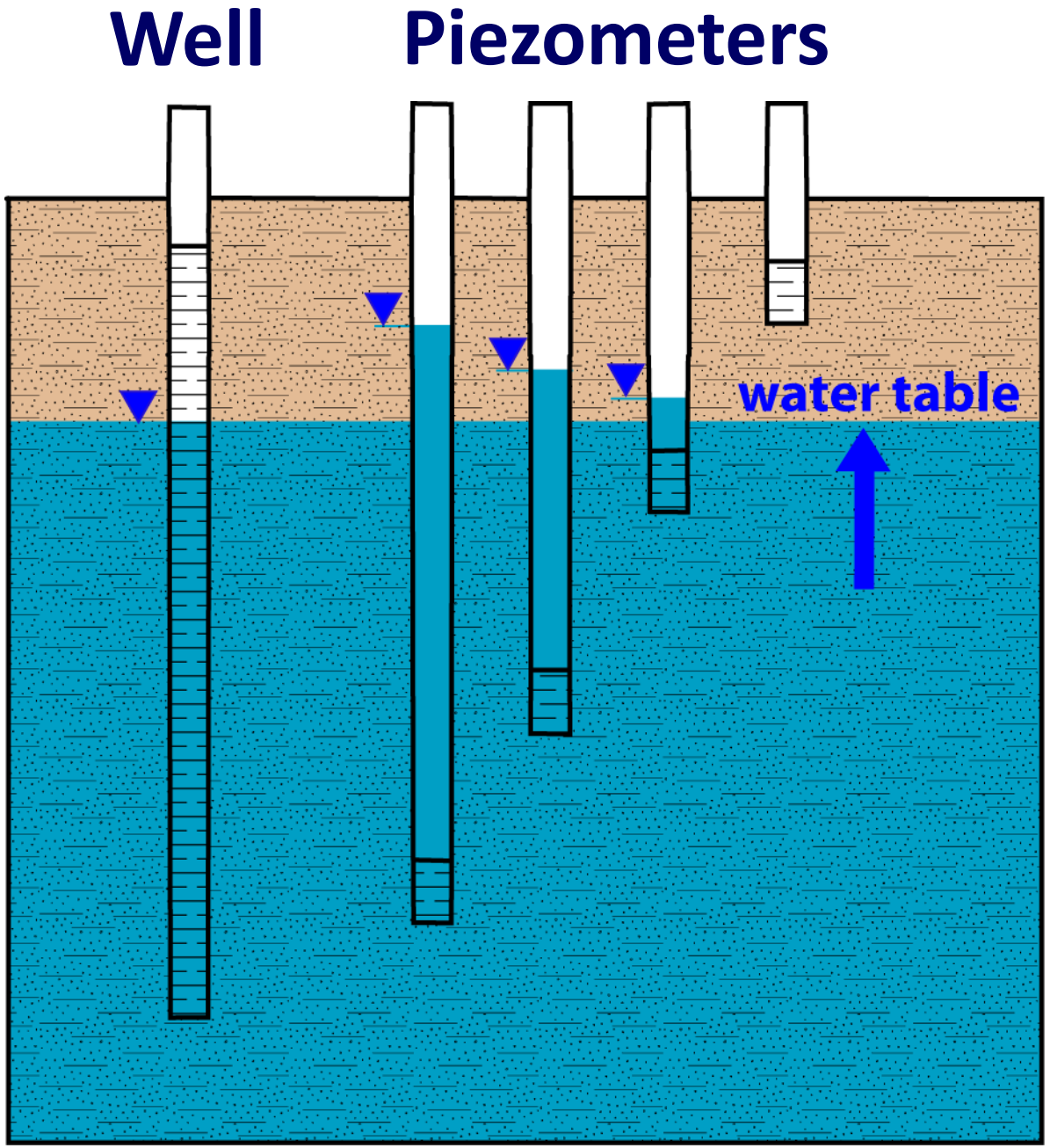
Rising Water Level - Discharge



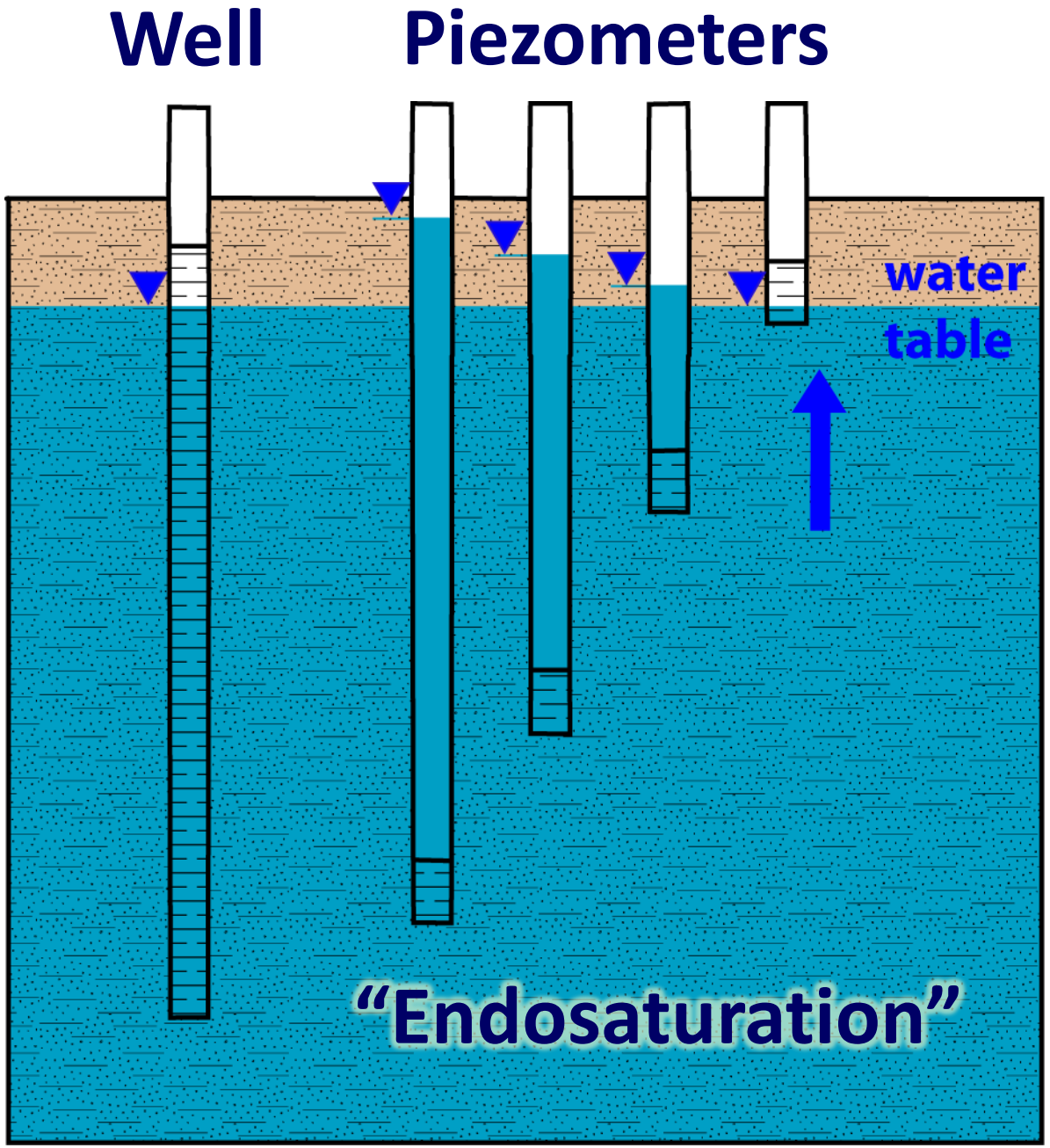
Rising Water Level - Discharge



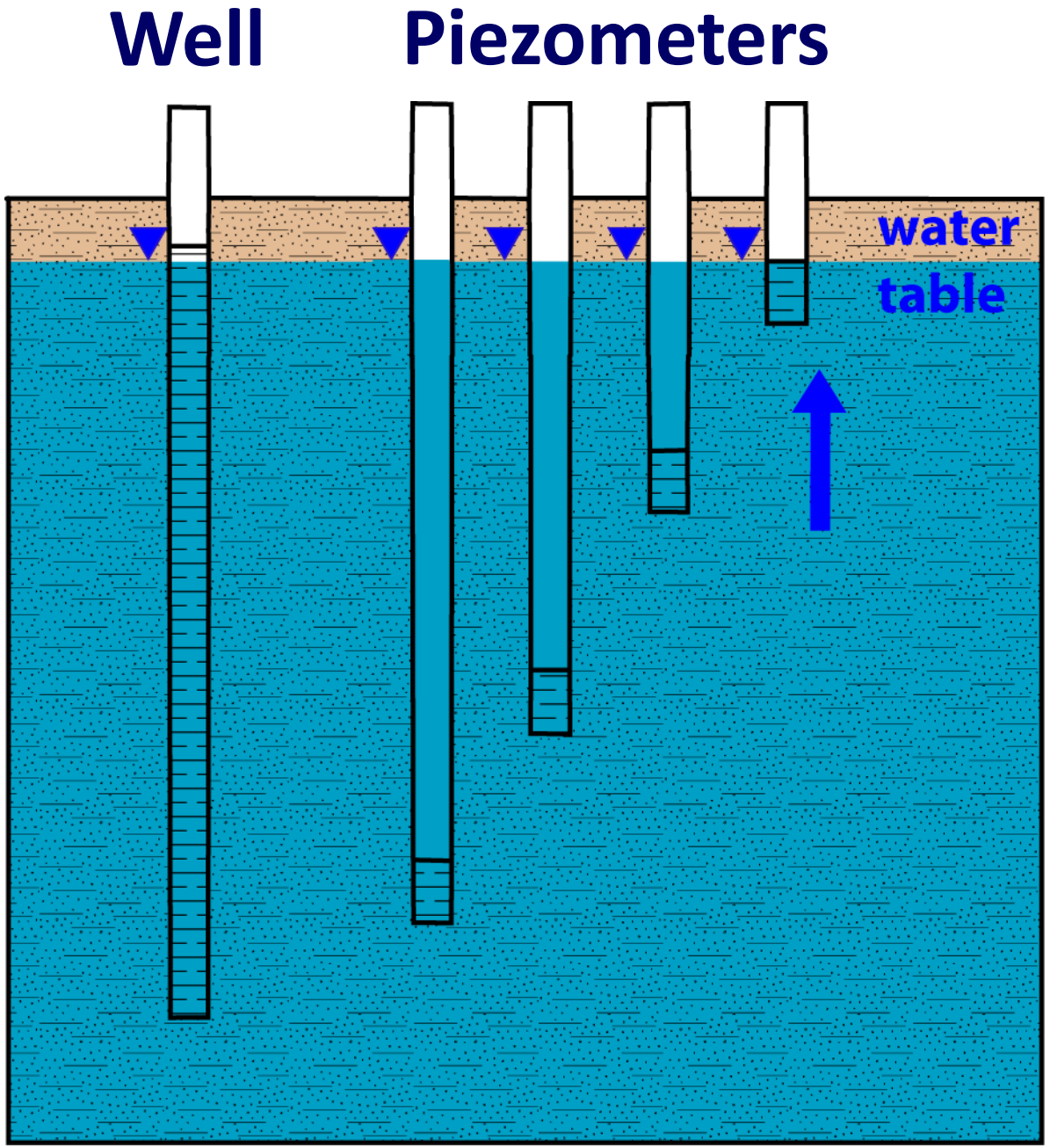
Rising Water Level - Discharge



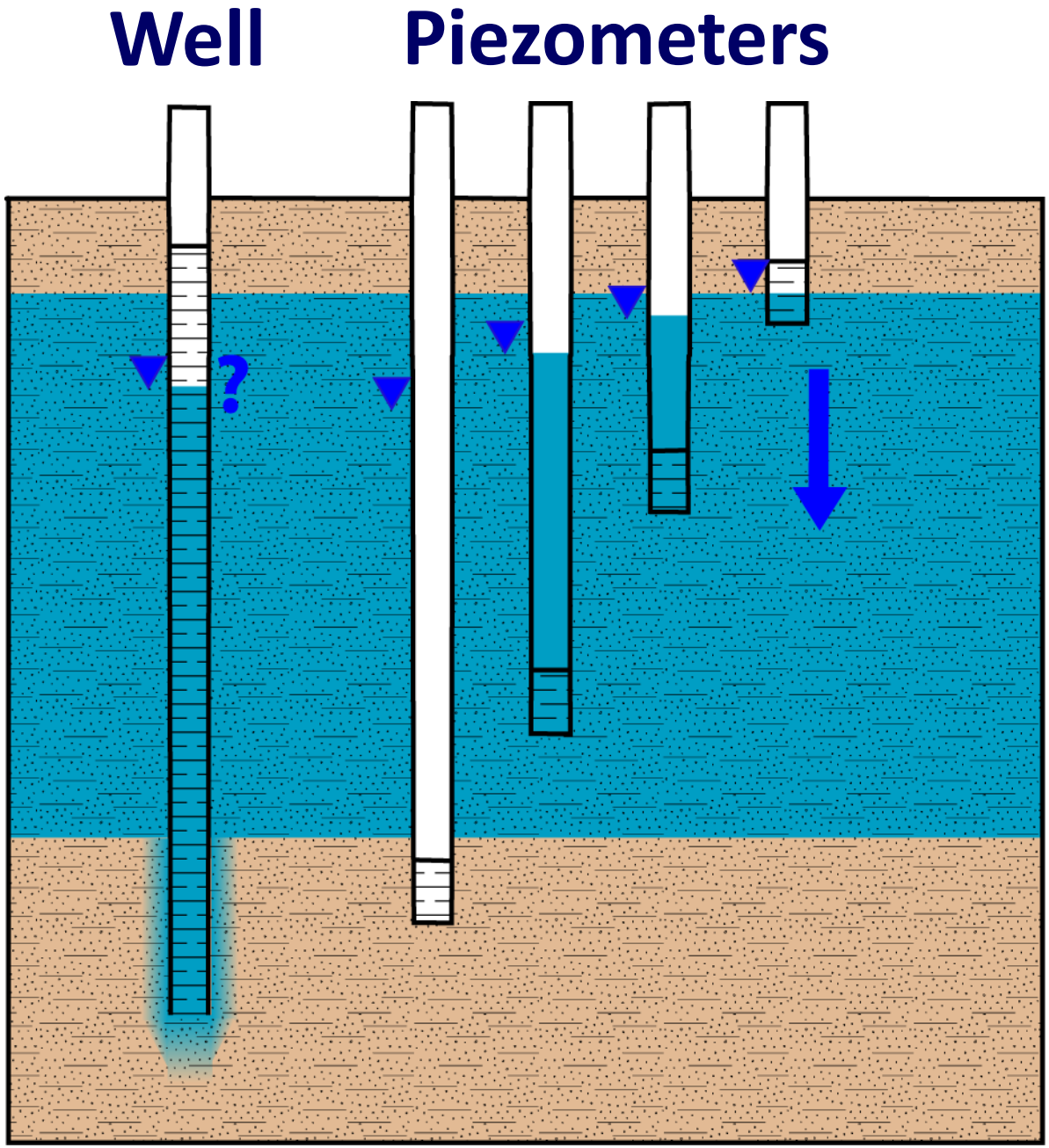
Rising Water Level - Discharge



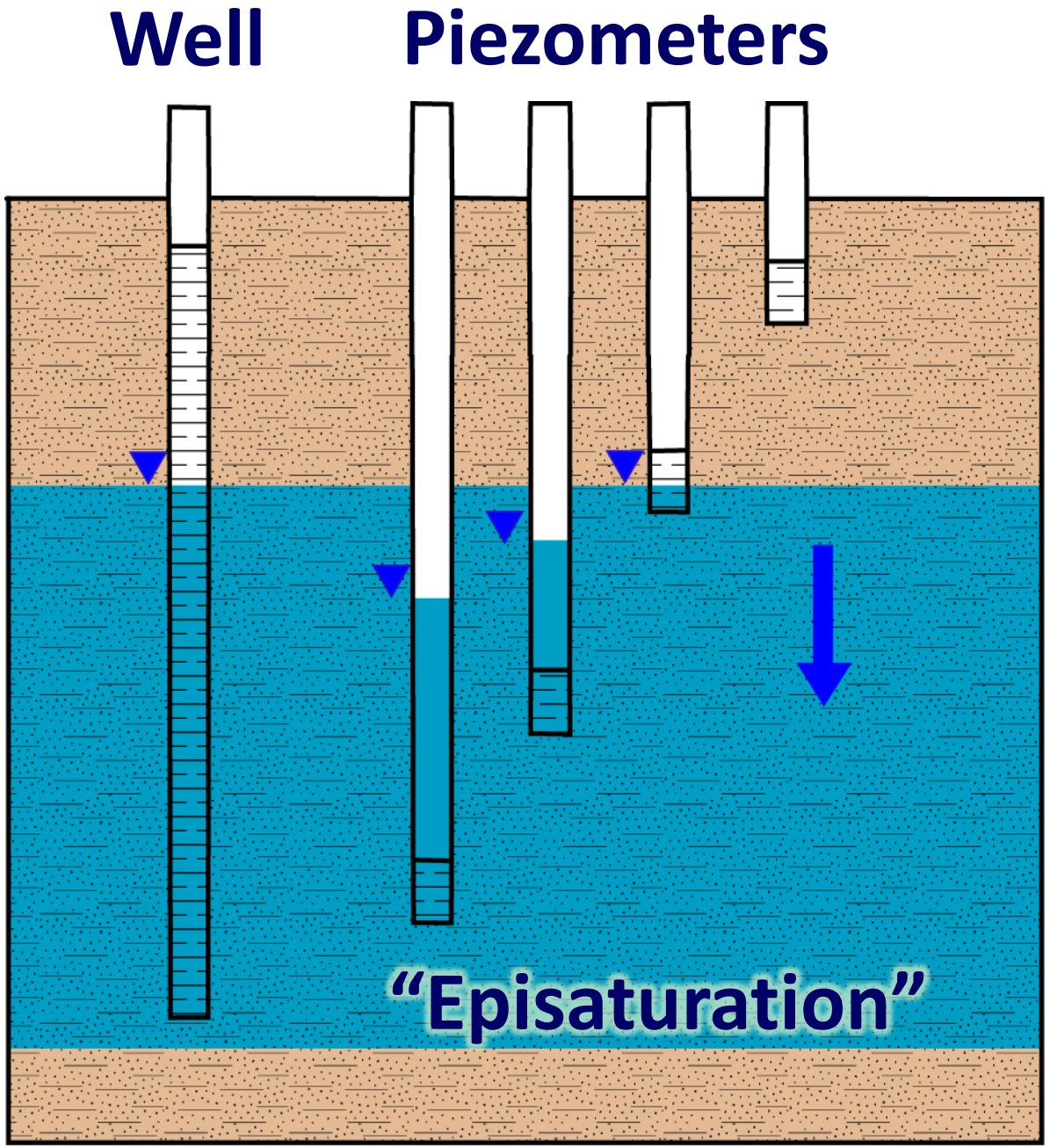
Static Water Level – no vertical flow – stagnant or flow-through



Falling Water Level - Recharge



Falling Water Level - Recharge



Wetland hydrology monitoring

- Planning
- Documentation
- Maintenance

Hydrologic Monitoring

Where to Monitor?

Hydrologic Monitoring

Monitoring locations should:

- Answer the question(s) being asked
- Use appropriate equipment
- Represent the site/area

Wetlands Regulatory Assistance Program

ERDC TN-WRAP-06-2
January 2006

Water Table Monitoring Project Design

by Chris V. Noble

Planning: How many locations?

- objectives of the study
- wetland size
- site complexity
- soil type(s)
- vegetative communities
- wetland type
- topographic relief

Boundary determination

- Need data from both sides of suspected boundary
- Transect(s) perpendicular to suspected boundary
- Only as accurate as the distance between the wells.

Hydrologic Monitoring - Site

Hydrologic Monitoring

How Deep?

Hydrologic Monitoring – Depths of Measurements

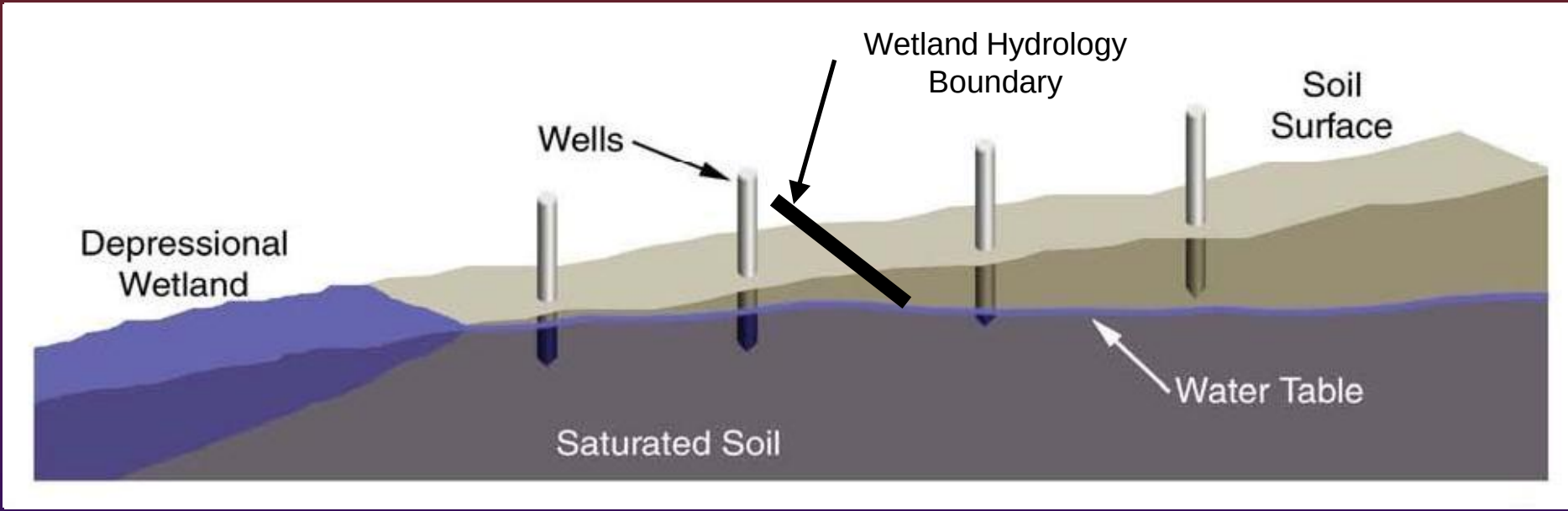
Question: Does the depth and timing of saturation at a location meet the technical criterion for wetland hydrology?

- 15 inch deep well (technical standard)
- Additional deeper well? 30-36” deep (or top of perching horizon)?

Additional deeper wells?

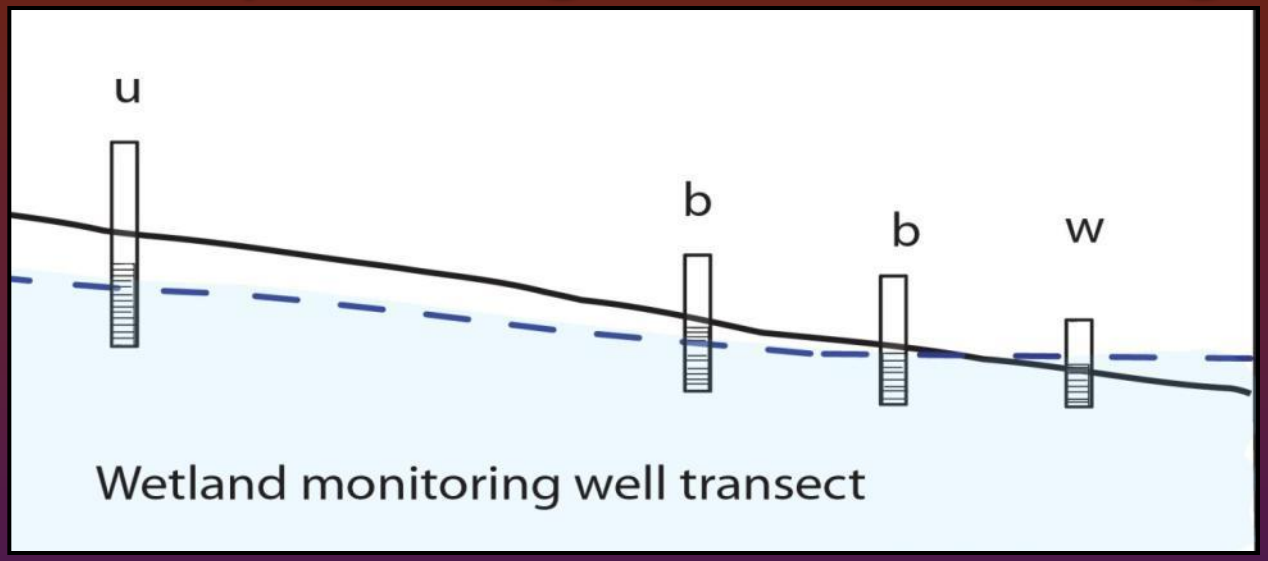
- Provide additional info about the water table.
- Usually installed deep enough to remain in contact with the water table year-round
- Data from a deeper well can alert those taking measurements to rising water table.

Hydrologic Monitoring - Site Depressional Wetland – Topographic Gradient



Question: Where is wetland hydrology boundary?

Hydrologic Monitoring - Site



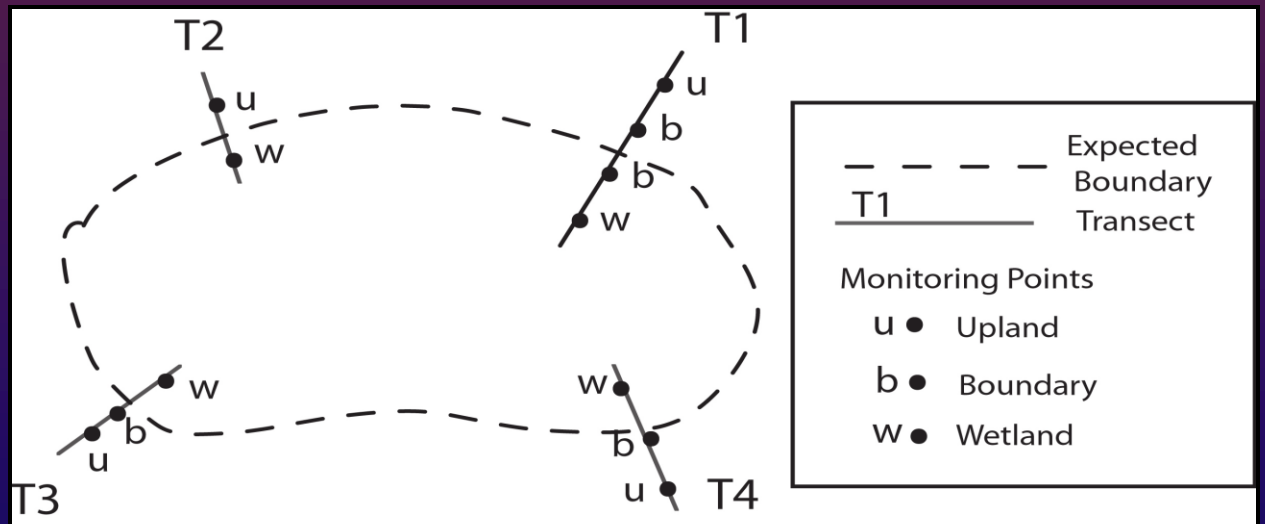
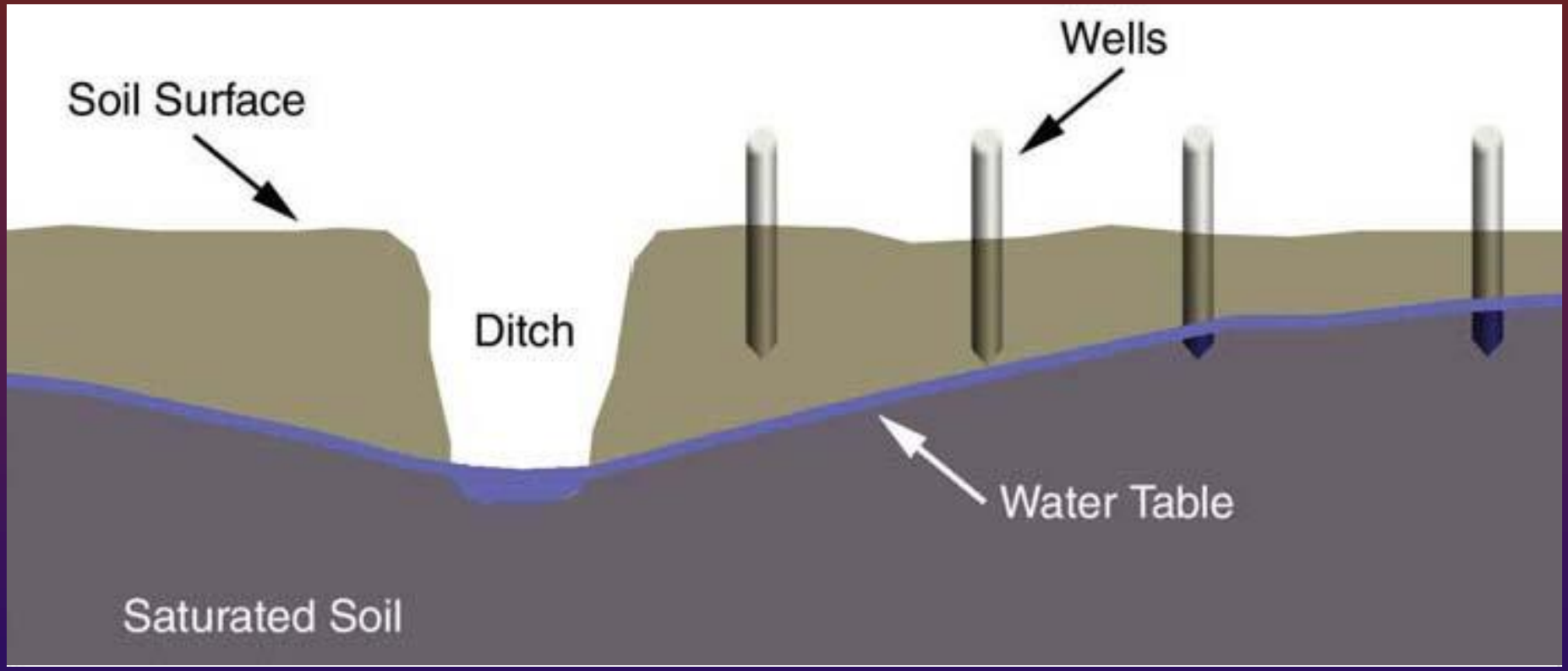
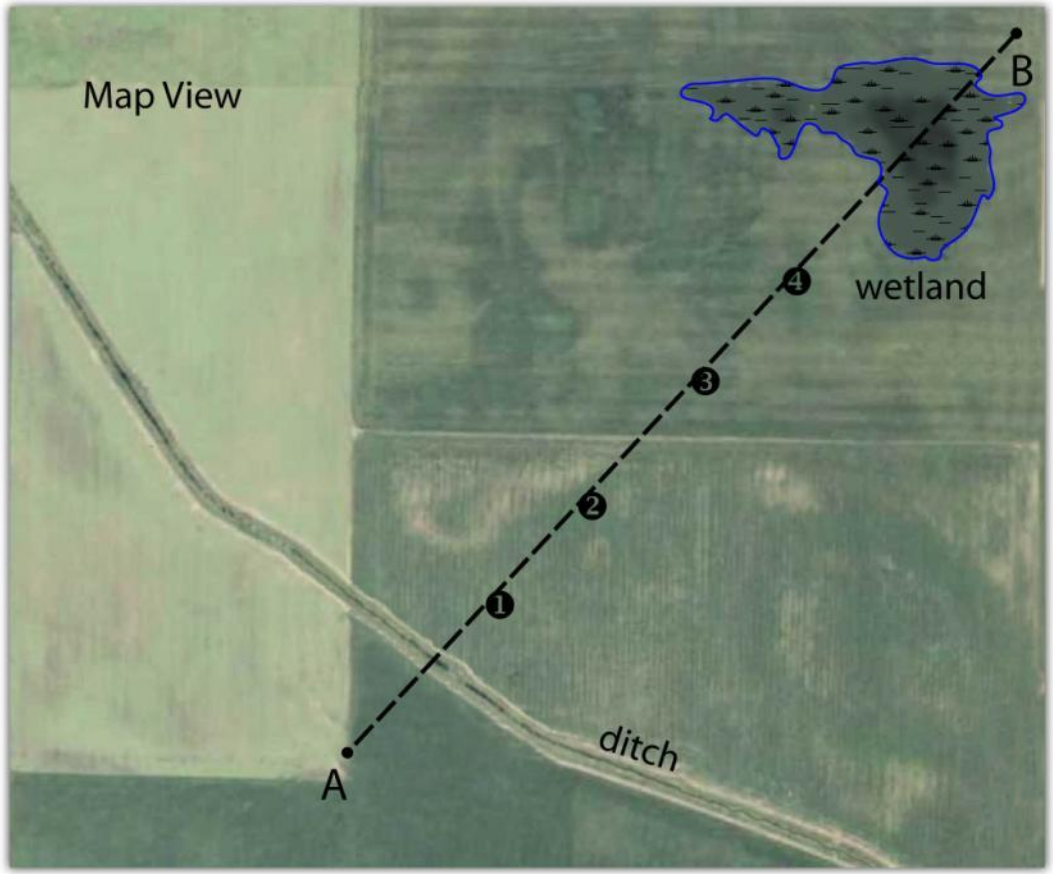


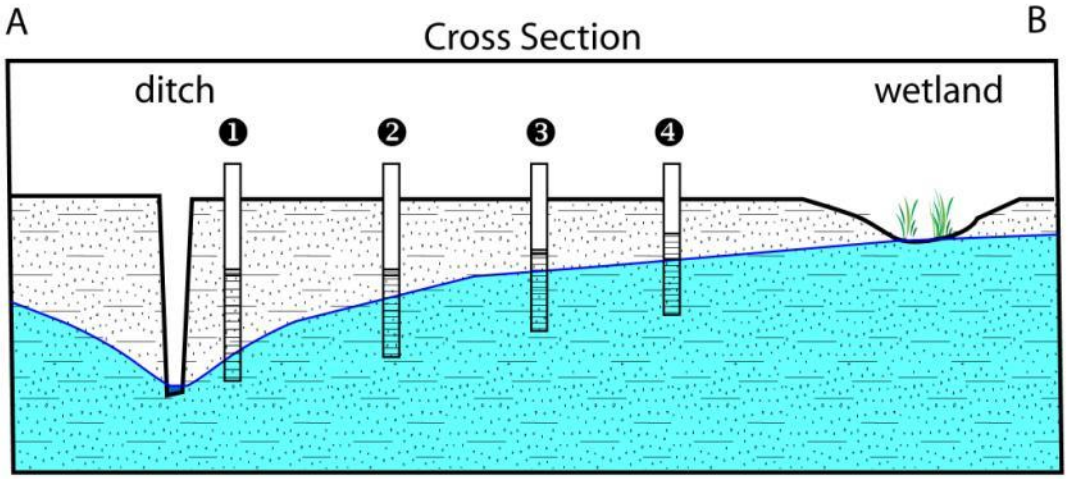
Fig. 3: Wetland monitoring project site

Hydrologic Monitoring – Site Altered Hydrology

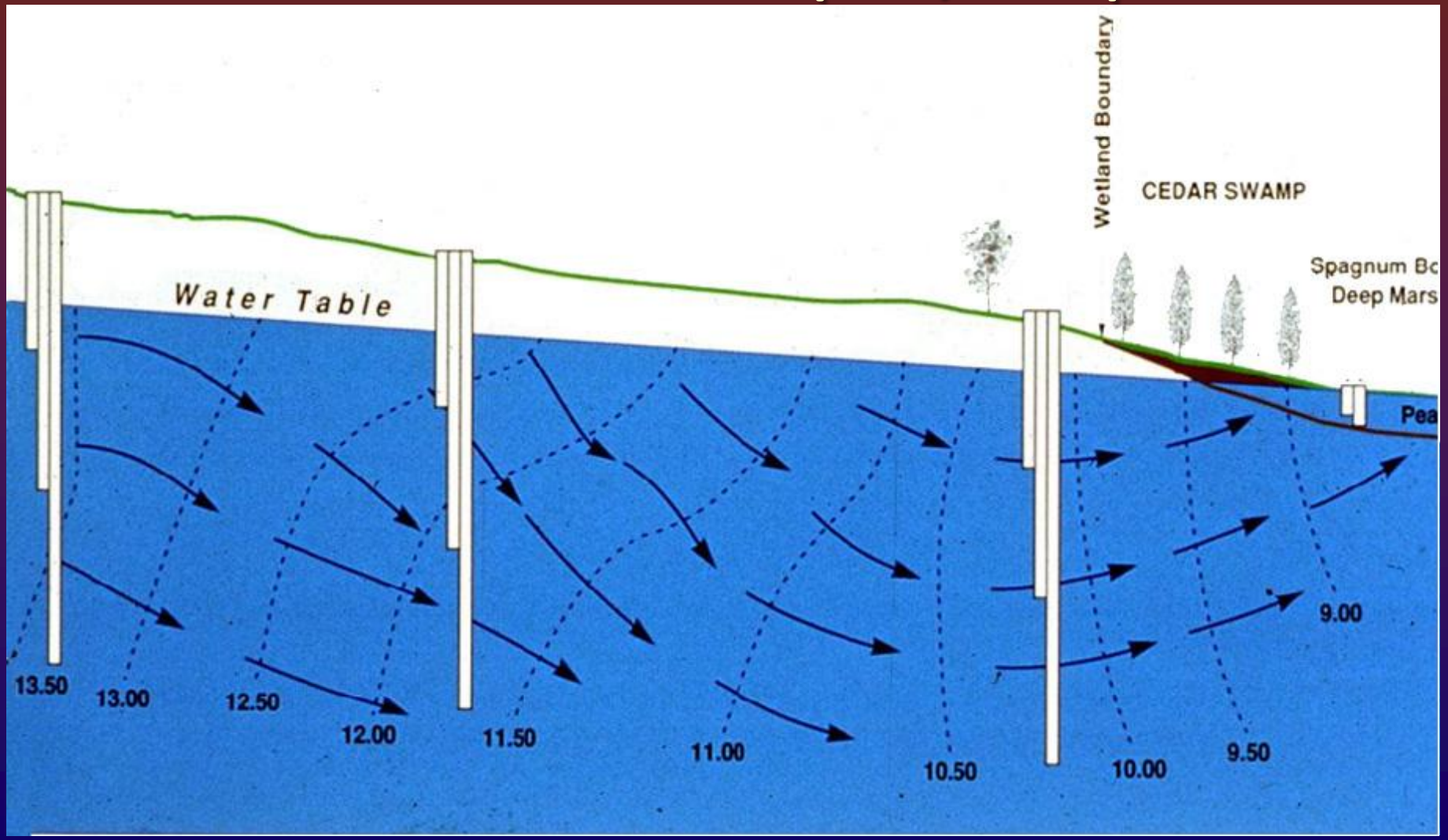


Objective: Determine lateral effect of drainage ditch.


Map View
B
wetland
4
3
2
1
ditch
A


A
Cross Section
B
ditch
wetland
1
2
3
4

Hydrologic Monitoring – Site Ground Water Input/output?



Construction & Installation

Construction & Installation

tnwrap00-2.pdf (application/pdf Object) - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://el.erdc.usace.army.mil/wrap/pdf/tnwrap00-2.pdf

tnwrap00-2.pdf (application/pdf Object)

http://el.erdc.usace.army.mil/wrap/pdf/tnwrap00-2.pdf

Wetlands Regulatory Assistance Program

ERDC TN-WRAP-00-02
July 2000

Installing Monitoring Wells/ Piezometers in Wetlands

PURPOSE: Wetland scientists frequently need quantitative information about shallow groundwater regimes near wetland boundaries and in adjacent uplands. Monitoring wells and piezometers are some of the easiest means of determining depth and movement of water tables within and immediately below the soil profile. Most of the literature on monitoring wells and piezometers, however, deals with installation to depths greater than needed for wetland regulatory purposes.

This revision of the original 1993 technical note reflects increased experience gained over several monitoring years from around the nation in the USDA-NRCS Wet Soils Monitoring project (*http://www.statlab.iastate.edu/soils/nssc/globhome.html#project9*) and other wetland research efforts.[1] Significant changes from the original version include:

- Recommending that 15-in. wells be used to test whether the hydrologic regime meets the criteria for wetland hydrology.
- Listing documentation needs.
- Eliminating well points except with commercially manufactured, automatic recording

8.50 x 11.00 in

http://el.erdc.usace.army.mil/wrap/pdf/tnwrap05-2.pdf

Wetlands Regulatory Assistance Program

ERDC TN-WRAP-05-2
June 2005

Technical Standard for Water-Table Monitoring of Potential Wetland Sites

by U.S. Army Corps of Engineers

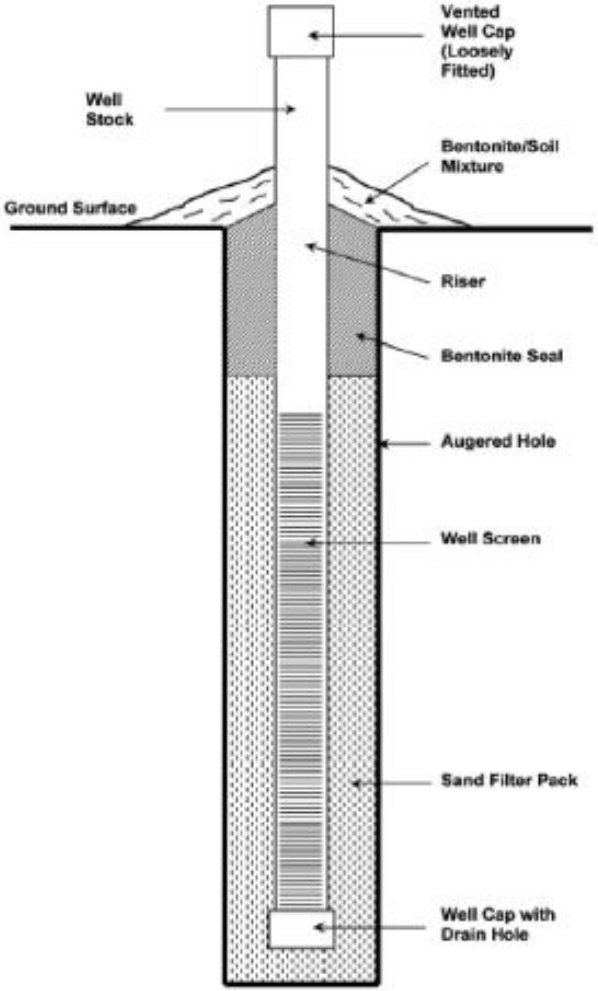
PURPOSE: This technical note describes national standards for the collection, analysis, interpretation, and reporting of hydrologic data, which may be used to help determine whether wetlands are present on disturbed or problematic sites that may be subject to Clean Water Act regulatory jurisdiction. These standards may be supplemented or superseded by locally or regionally developed standards at the discretion of the appropriate Corps of Engineers District.

BACKGROUND: Wetland determinations in the majority of cases are based on the presence of readily observable field indicators of hydrophytic vegetation, hydric soils, and wetland hydrology, according to procedures given in the *Corps of Engineers Wetlands Delineation Manual* (Environmental Laboratory 1987) (hereafter called the Corps Manual). These three characteristics

USDA NRCS
United States Department of Agriculture
Natural Resources Conservation Service

Installing Monitoring Wells in Soils

Version 1.0
August 2008

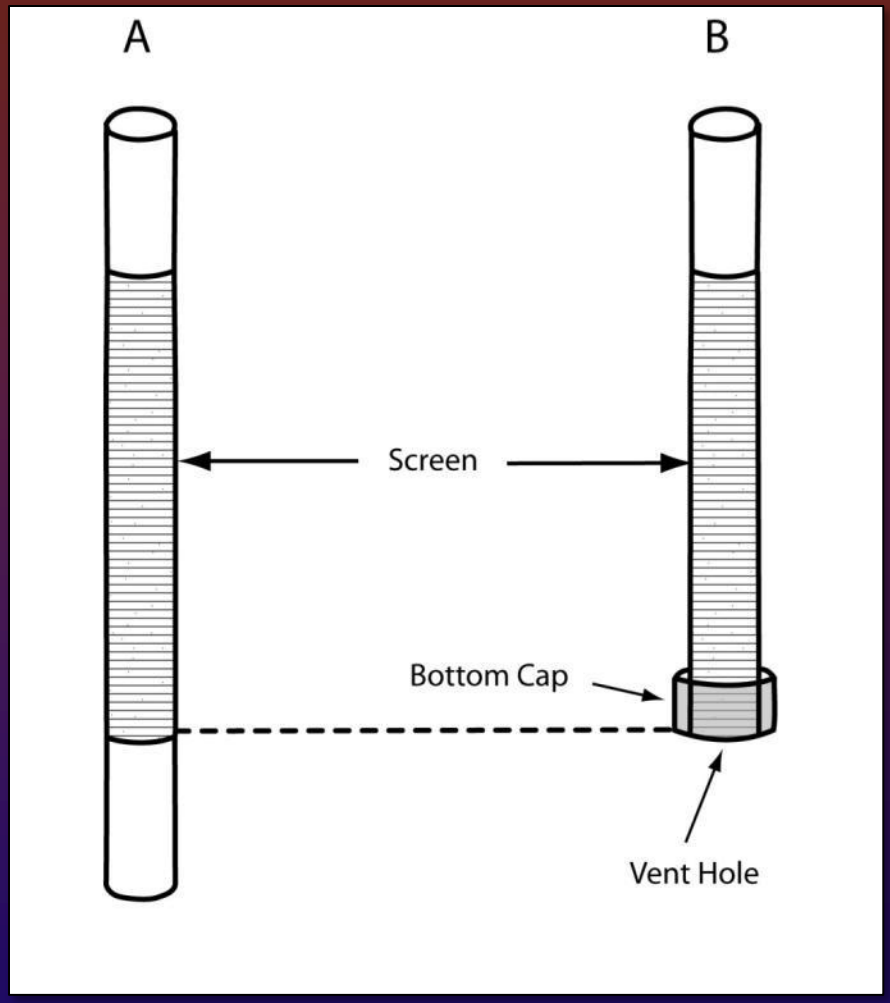


http://soils.usda.gov/technical/

USDA – NRCS
National Soil Survey Center
Lincoln, Nebraska

Construction

- 1-2” diameter PVC pipe
- Commercial well screen
  - 0.01 inch wide screen
  - 20-40 clean sand



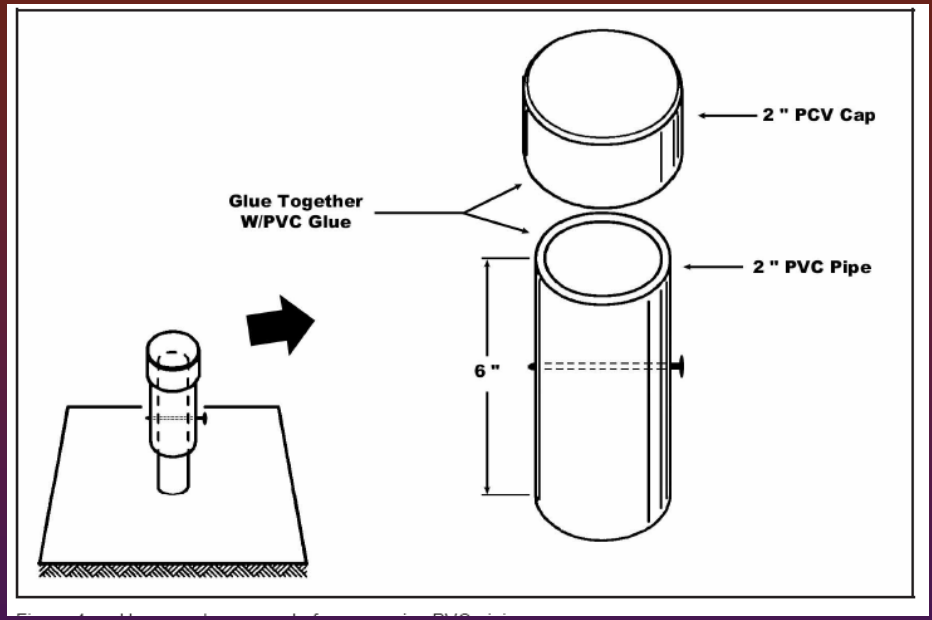
I like 1 ¼ inch PVC well screen

Filter Fabric

Filter Socks

- Not necessary with sand pack
- Used in mucky or peat soil or where permanently saturated

Construction



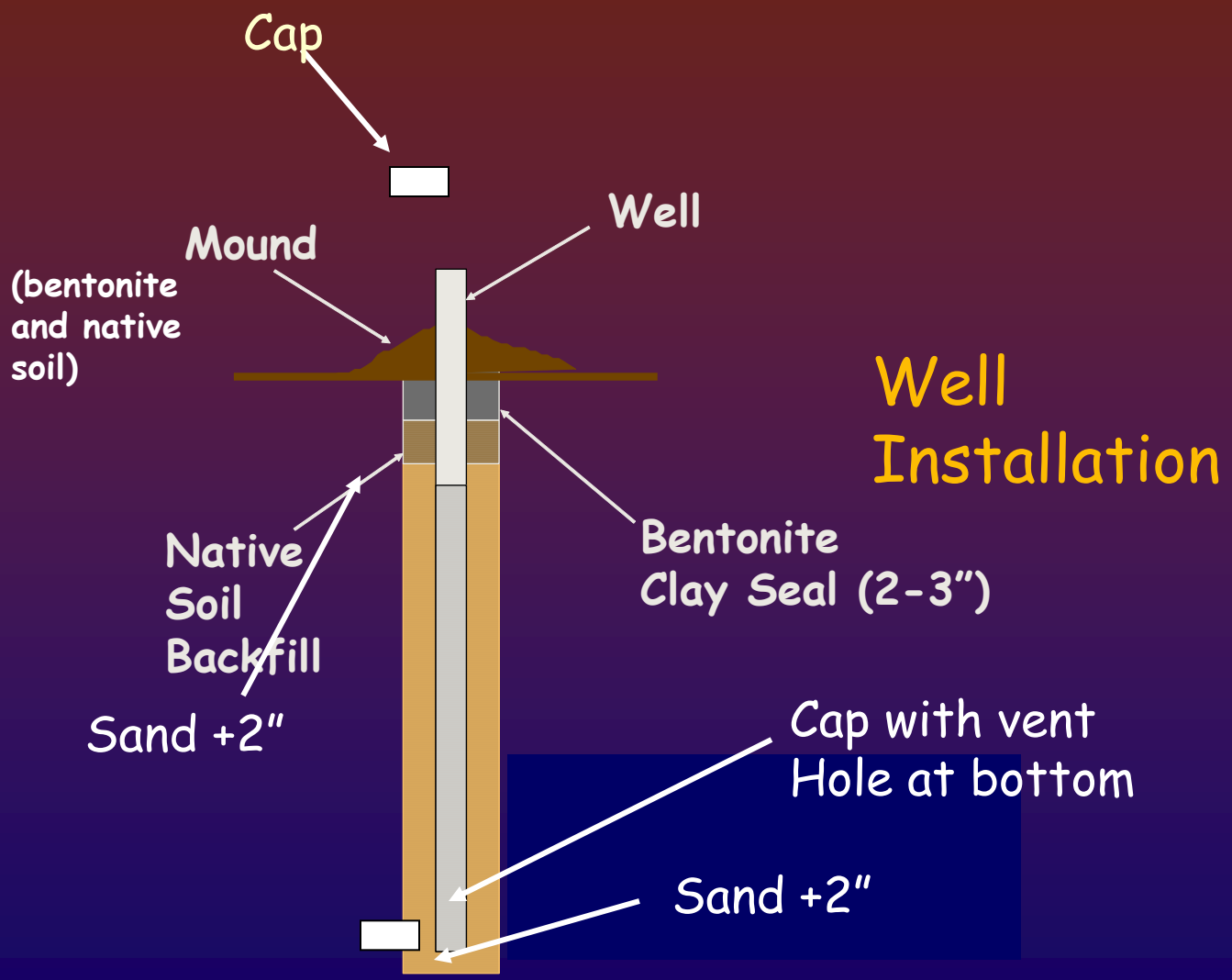
Riser

- Solid 1st 6” below ground surface
- Extend 12” above ground surface, unless site requires more/less

Well Cap

- Prevent rainfall contamination

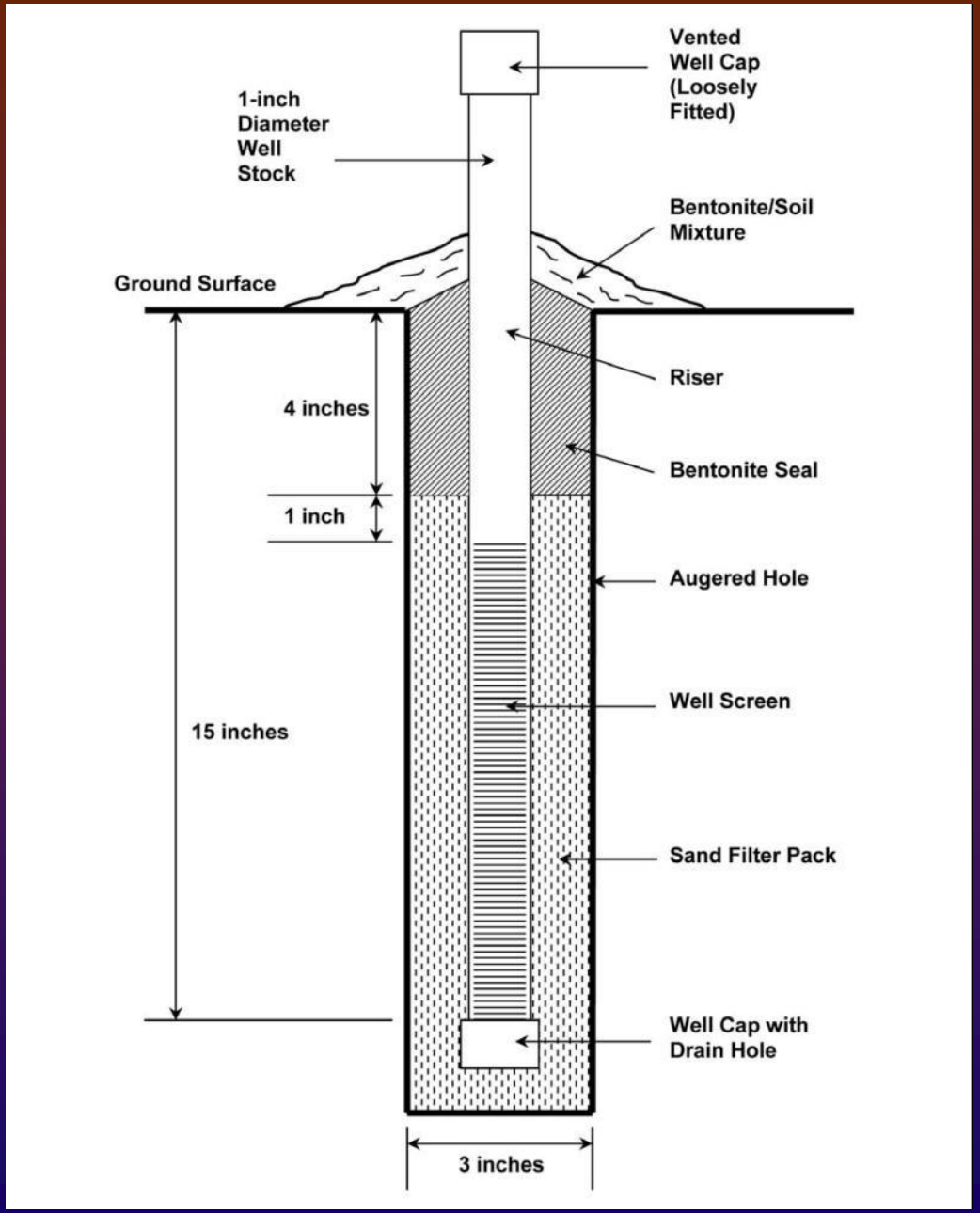
Installation of a Well



Well Installation

Standard 15-inch monitoring well installed by augering.

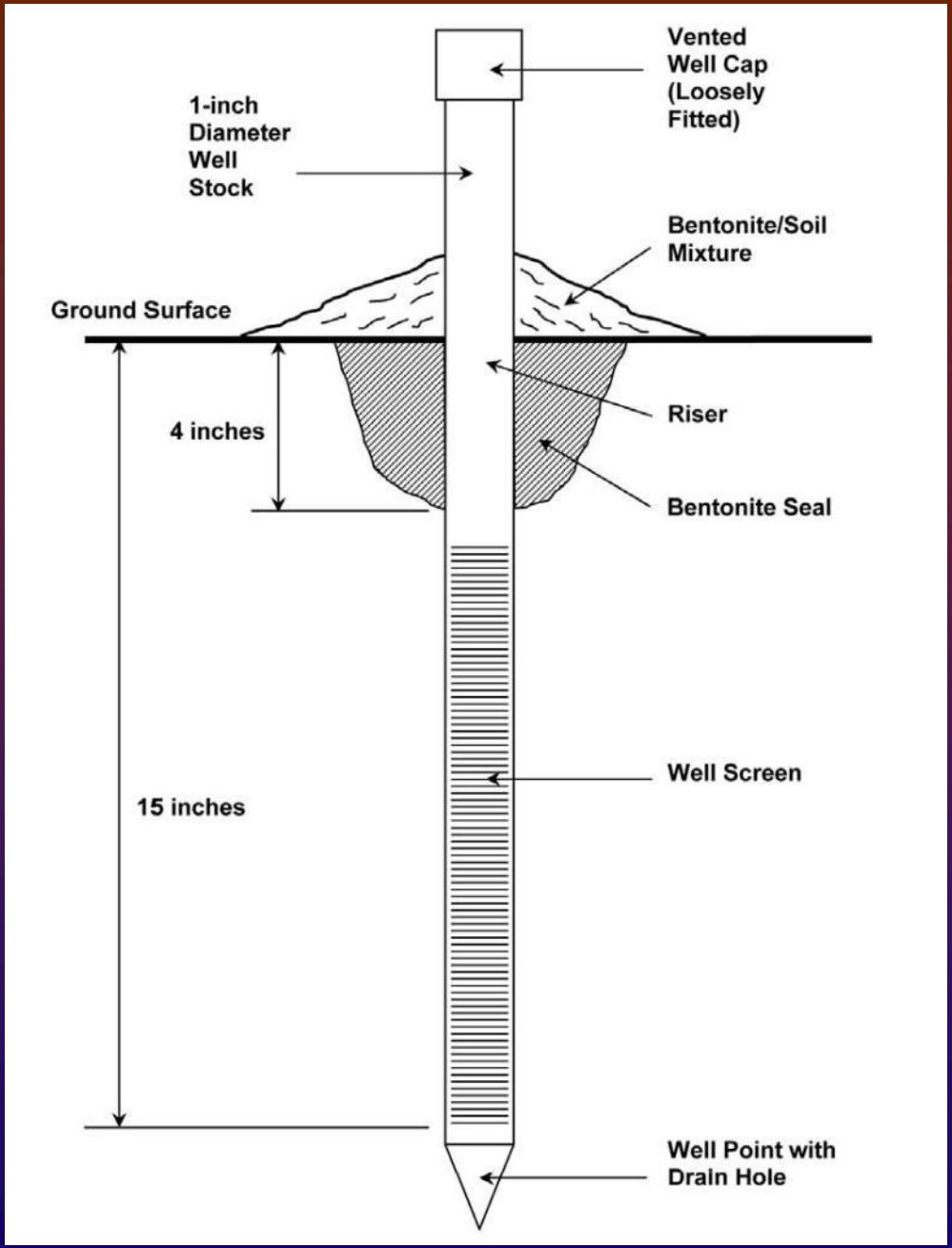
From: U.S. Army Corps of Engineers Technical Standard for Water-Table Monitoring of Potential Wetland Sites



http://el.erdc.usace.army.mil/wrap/pdf/tnwrap05-2.pdf

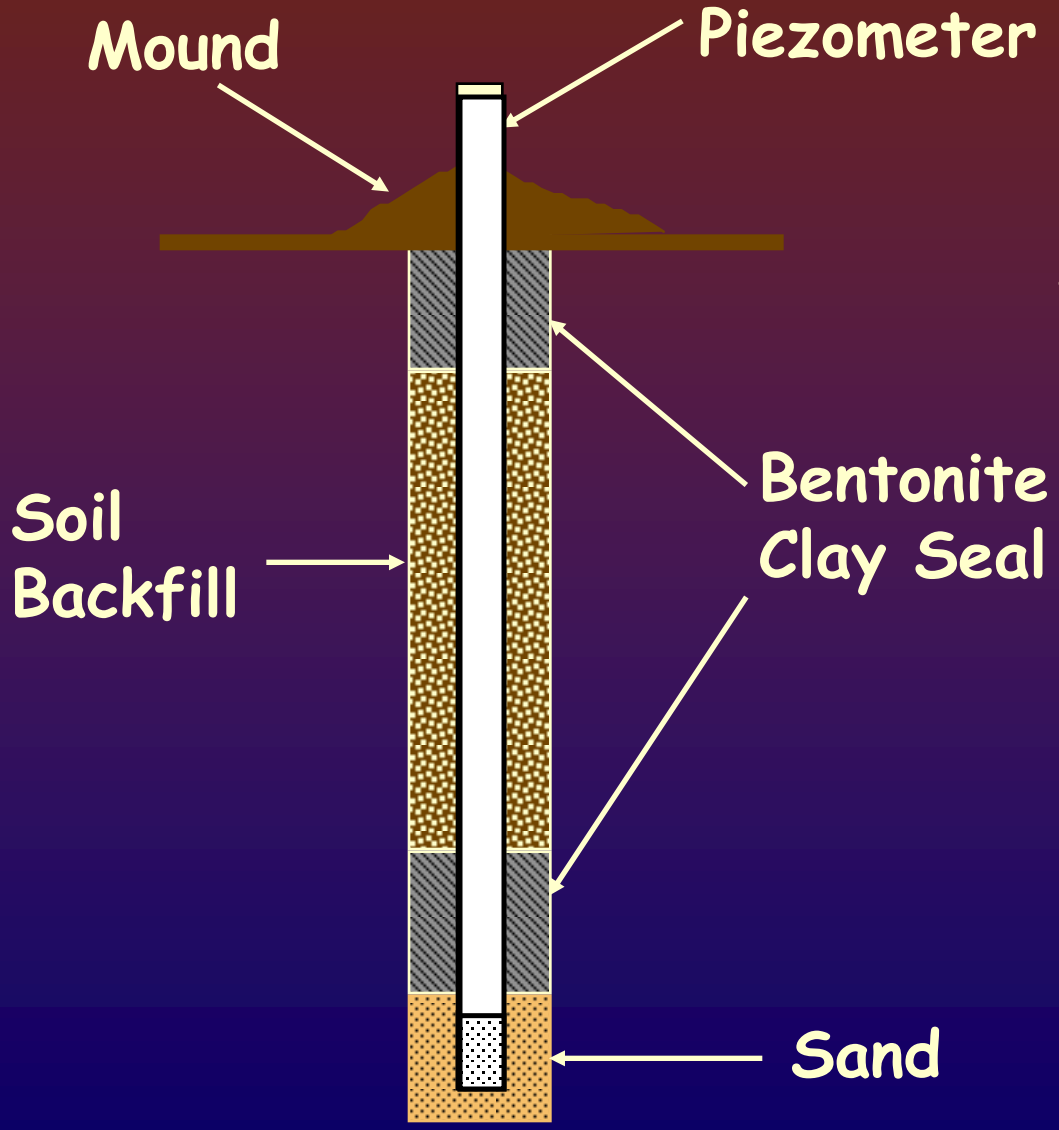
Standard 15-inch monitoring well installed by driving.

From: U.S. Army Corps of Engineers Technical Standard for Water-Table Monitoring of Potential Wetland Sites



http://el.erdc.usace.army.mil/wrap/pdf/tnwrap05-2.pdf

Installation of a Piezometer



Piezometer
Installation

Installation Equipment

- Auger with extensions
- Coloring book/water – soil description
- Well/piezometers – pre-made lengths or supplies to build in field
- Tamper
- Scarifier
- Bentonite
- Sand
- Tape measure
- Perm. markers to label equipment
- Installation data sheet(s)

Dutch Auger at the ready….

Logging the boring…

Checking depth…

Scarify…

Here Comes the Sand…

Adding Sand…

Tamping

Adding
Bentonite Seal…

Almost
Done

Construction - Protection

Protection Needed?
Depends on:
- Potential for vandalism
- Animals
- Planned burning

Possibilities
- Steel riser
- Protection post
- Outer casing, cover, shelter
- Locking well cap

Equipment Maintenance

Check for clogging

- Fine textures
- Pump and wait for equilibrium (saturated)
- Add water and time to drain (unsaturated)

Verify instrument elevations

- Freeze/thaw, wet/dry cycles move equipment
- Annual spring tradition

Vandalism protection

- Hide instruments, armor
- ID with signs

Documentation

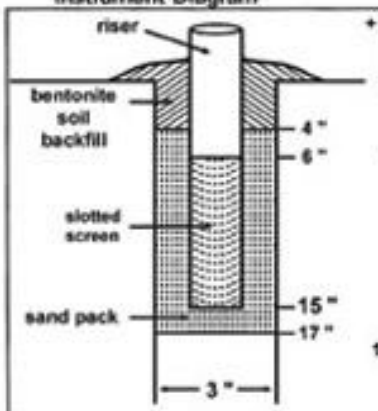
- Location of wells – site map
- Well construction details
- Soil/ geology log

Installation Data Sheet

Project Name *Alpha Project* Date of Installation *9/9/99*
Project Location *Beta Place* Personnel *J Doe*
Well Identification Code *A-15* *J Bloe*
Attach map of project, showing well locations and significant topographic and hydrologic features.
As appropriate, attach map of well site, showing locations and ground elevations of all instruments and microtopographic features of significance, with respect to reference datum.

Type of Instrument
Source of instrument / well stock *Acme Well Company*
Material of well stock *Schedule 40 PVC* Diameter of pipe *1 inch*
Slot size *0.010 inch* Slot spacing *0.5 inch*
Kind of well cap *homemade PVC w/vent* Kind of end plug *1" plug, vented*
Nature of Installation Materials
Nature of packing sand *20-40 silica* Kind of bentonite *chips*
Nature of backfill *bentonite/soil mix* Depth of backfill *6 in to ground surface*
Was bentonite installed below groundwater depth at installation? *NA*
Was water added to bentonite for expansion? *NA*
Method of measuring water levels in instrument *steel tape and soluble marker*
How was instrument checked for clogging after installation? *Water poured down well and drainage monitored. No water standing in well after 20 minutes.*

Instrument Diagram



Soil Characteristics

	Texture	Structure	Roots	Consis-tence	Redox Features
0 "	*silt loam*	*strong granular*	*many medium*	*very friable*	*none*
6 "	*silt loam*	*weak sub-angular blocky*	*common*	*friable*	*2.5Y5/1 matrix common Fe-concentrations*
18 "	*silty clay loam*	*moderate blocky*	*few fine*	*very firm*	*10YR 4/1 matrix many Fe-concentrations & depletions*
36 "	*silty clay loam*	*weak sub-angular blocky*		*very firm*	*10YR 5/1 matrix common Fe-concentrations & depletions*

Documentation of well installation details and soil characteristics is essential for valid interpretation of monitoring well data!

Minnesota Board of Water & Soil Resources
Hanson Wetland Bank– Soil Boring / Well Construction

A1

Date: 7/19/2010 **County:** Murray **Site ID:** enter site ID

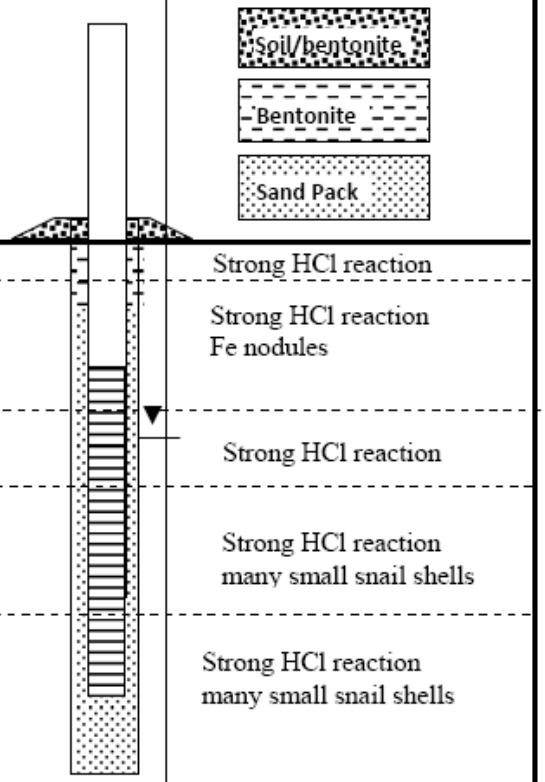
Personnel: E Mohring, M Lennon, K Radel **Equipment/ Method:** dutch auger

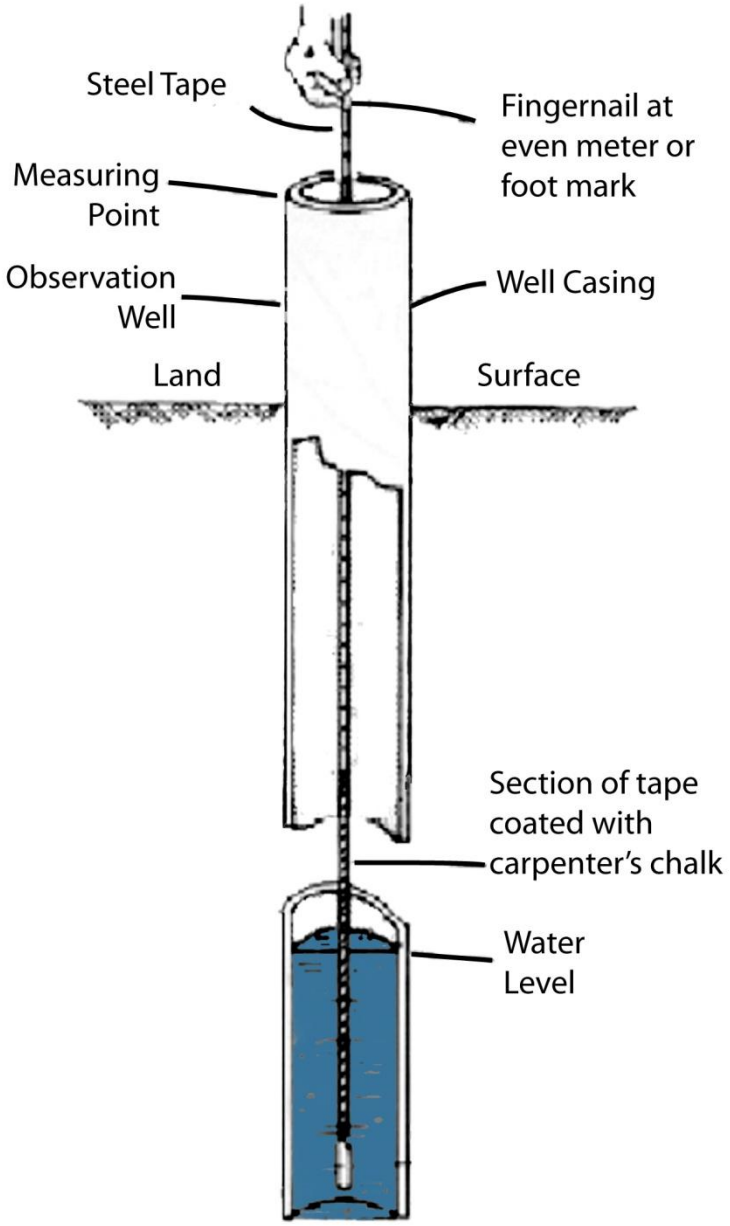
Landscape Position: footslope **Soil Series:** 86 Canisteo clay loam **Parent Material:** till

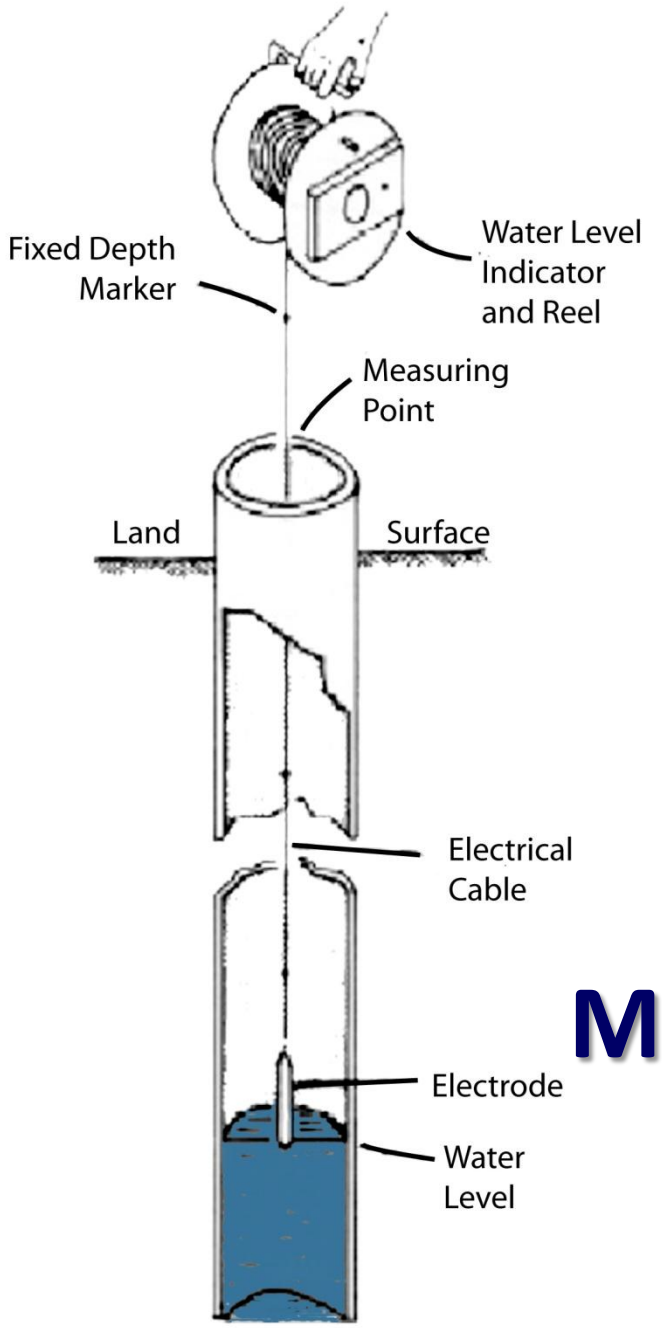
Water depth during installation: 1.3 ft **Pack material:** sand **Backfill material:** native clay

Well	Diam (in)	Screen type	Slot (in)	screen length (ft)	screen interval (ft)	end plug type	riser	riser length (ft)	total (ft)	Stick -up (ft.)	depth (ft)	pack interval	seals	surface completion
A1	1 ¼"	sch 40 pvc wrapped	.010	2.3	.75 – 3.05	capvented	sch 40 PVC	3.0	5.3	2.25	3.05	.5 – 3.5	bentonite 0-.5 ft bent/sand/clay mound	oversize PVC cap

Depth (ft)	Texture, etc.	Color Matrix	Color Redox	Wells	Remarks
	texture wet	H V C	% H V C size prom		
0	fibric peat, moist	10YR 4/2			Strong HCl reaction
--	sapric peat, moist to wet	10YR 2/1	5% 2.5YR 5/6		Strong HCl reaction Fe nodules
1--	loam, moist to wet	10YR 3/1	20% 10YR 5/1		Strong HCl reaction
--					
2--	loam, wet	10YR 4/1 (60%)	40% 10YR 5/1		Strong HCl reaction many small snail shells
--	loam, wet	10YR 4/1	15% 10YR 7/1		Strong HCl reaction many small snail shells
3--					
--	End of boring				
4--					





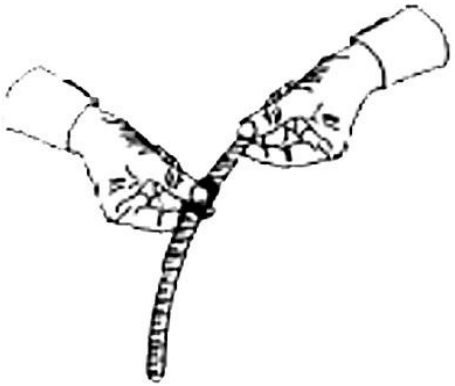


Measuring Water Levels

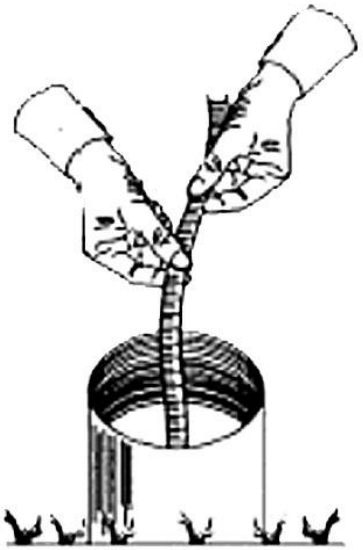
Steel Tape and Chalk…

Depth to water from measuring point
="HOLD" number minus "CUT" number.

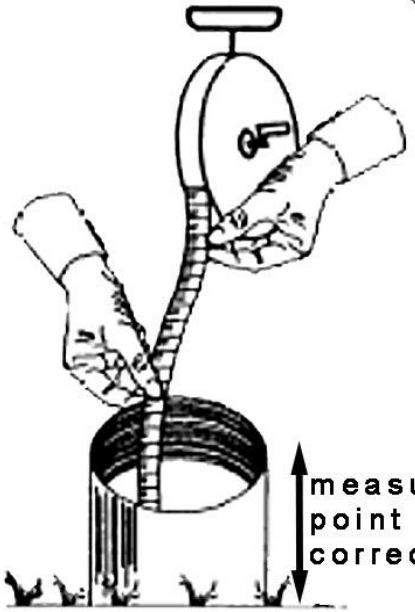
Depth to water from Land Surface
= depth to water from measuring point
minus measuring point correction("stick-up").



1. Chalk the tape

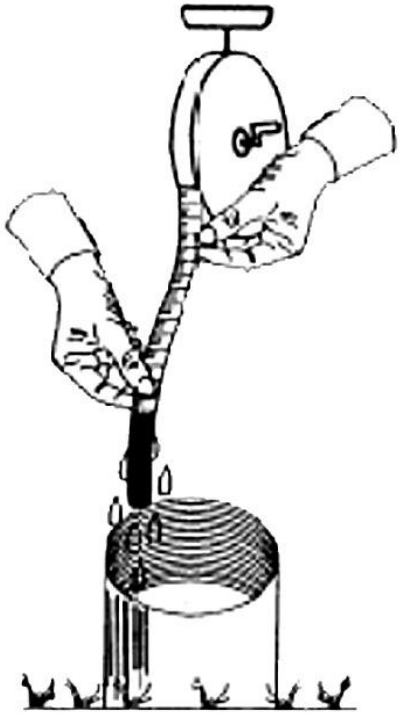


2. Lower the tape
and hold the number.



3. Put the "HOLD"
number by the
measuring point

4. Reel the tape
out of the well



5. Read the "CUT"

Electric water-level meters…..

Pressure transducers & data loggers…

Documentation of well installation details and soil characteristics is essential for valid interpretation of monitoring well data!

Interpreting the data……

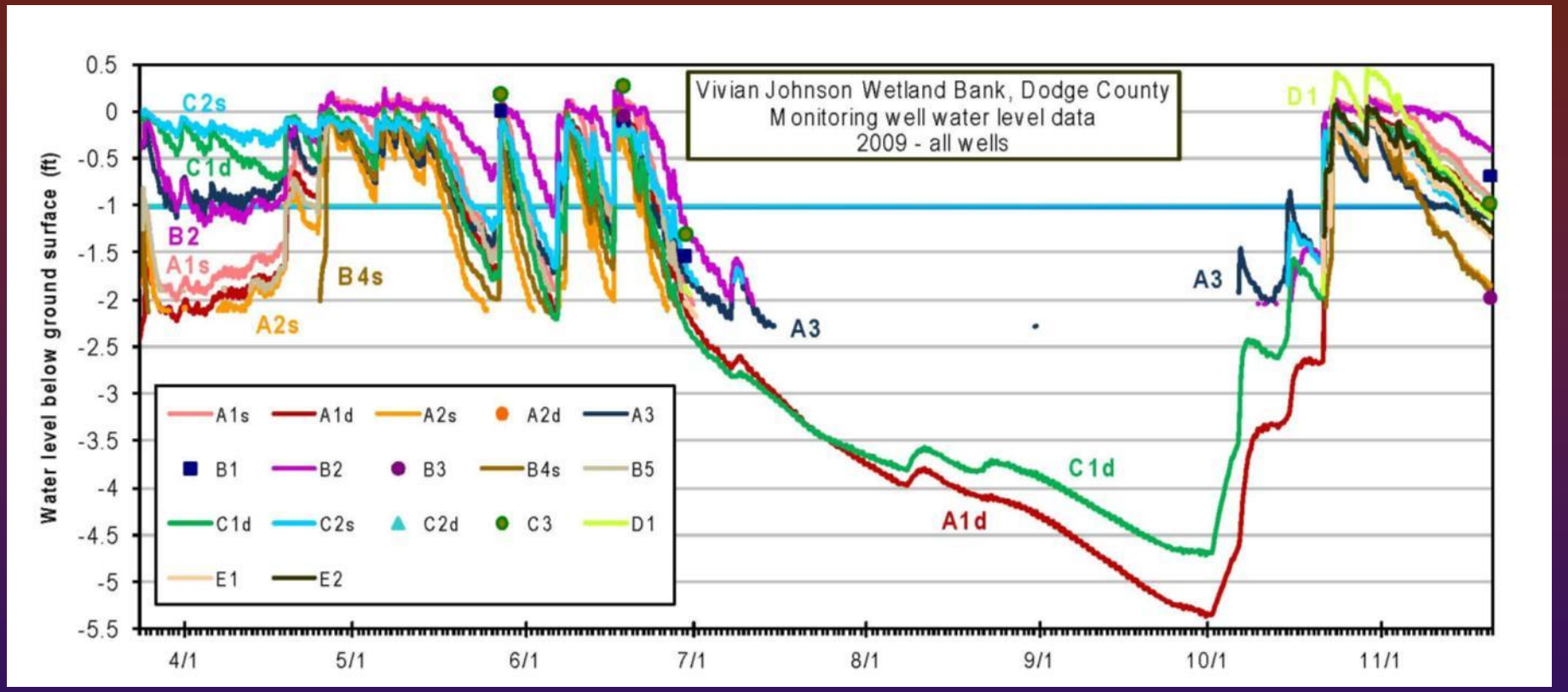
G159 =+D159-F159

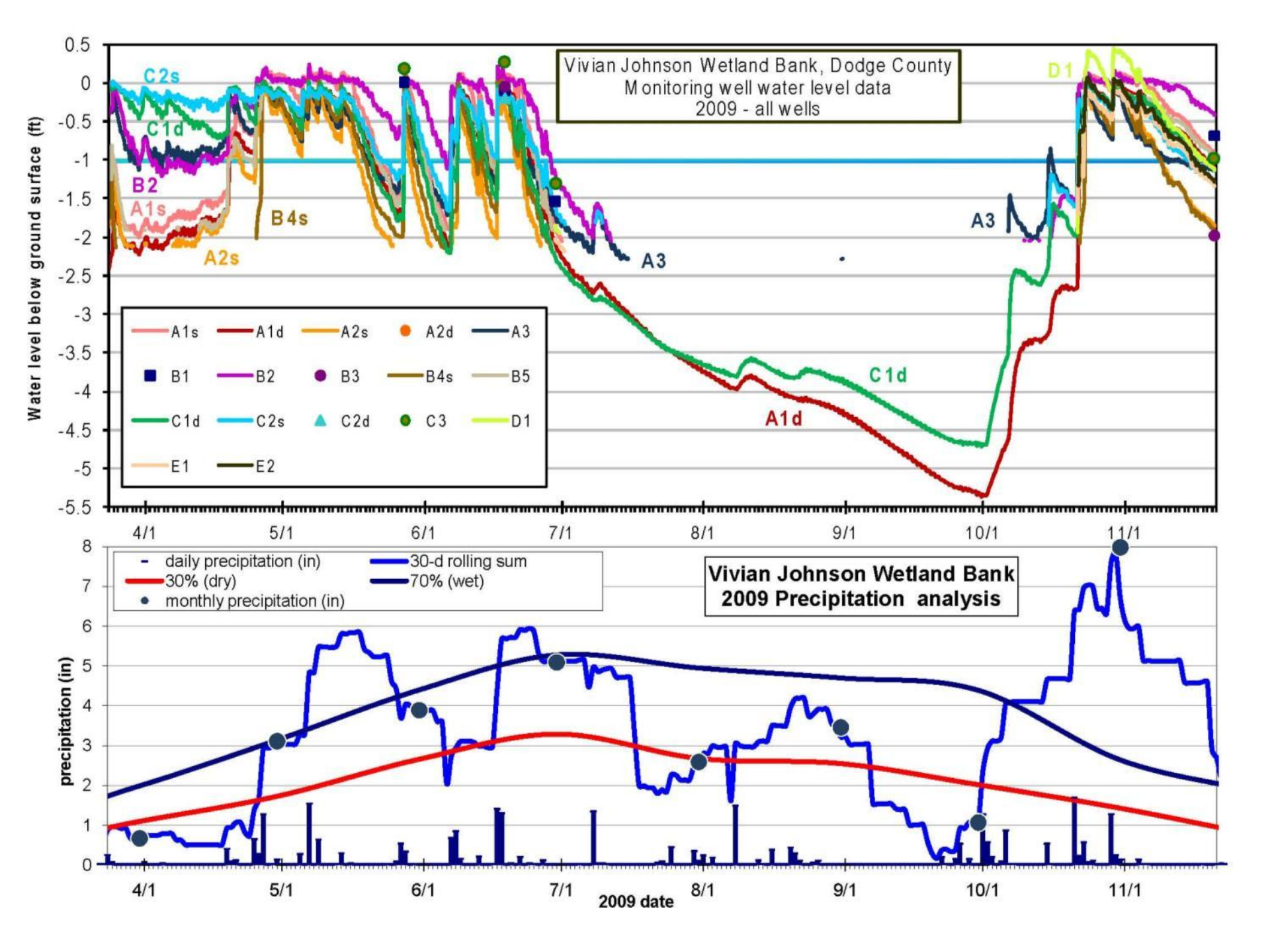
	A	B	C	D	G	H	I	K
7	Date	Time	Date/Time	logger level (ft)	calc logger wl below toc (ft)	stickup (ft)	calc logger wl below gs (ft)	T (°C)
152	3/23/09	14:00	3/23/09 14:00	0.6006	-2.98	1.40	-1.58	0.34
153	3/23/09	16:00	3/23/09 16:00	0.5551	-3.02	1.40	-1.62	0.38
154	3/23/09	18:00	3/23/09 18:00	0.5055	-3.07	1.40	-1.67	0.41
155	3/23/09	20:00	3/23/09 20:00	0.4739	-3.11	1.40	-1.71	0.45
156	3/23/09	22:00	3/23/09 22:00	0.4700	-3.11	1.40	-1.71	0.48
157	3/24/09	0:00	3/24/09 0:00	0.5069	-3.07	1.40	-1.67	0.47
158	3/24/09	2:00	3/24/09 2:00	0.6763	-2.90	1.40	-1.50	0.40
159	3/24/09	4:00	3/24/09 4:00	0.6706	-2.91	1.40	-1.51	0.42
160	3/24/09	6:00	3/24/09 6:00	0.6373	-2.94	1.40	-1.54	0.44
161	3/24/09	8:00	3/24/09 8:00	0.6050	-2.97	1.40	-1.57	0.47
162	3/24/09	10:00	3/24/09 10:00	0.5882	-2.99	1.40	-1.59	0.49
163	3/24/09	12:00	3/24/09 12:00	0.5899	-2.99	1.40	-1.59	0.51
164	3/24/09	14:00	3/24/09 14:00	0.6098	-2			
165	3/24/09	16:00	3/24/09 16:00	0.6309	-2			
166	3/24/09	18:00	3/24/09 18:00	1.1787	-2			
167	3/24/09	20:00	3/24/09 20:00	1.2047	-2			
168	3/24/09	22:00	3/24/09 22:00	1.1607	-2			
169	3/25/09	0:00	3/25/09 0:00	1.1579	-2			
170	3/25/09	2:00	3/25/09 2:00	1.1363	-2			
171	3/25/09	4:00	3/25/09 4:00	1.1083	-2			
172	3/25/09	6:00	3/25/09 6:00	1.0861	-2			
173	3/25/09	8:00	3/25/09 8:00	1.0499	-2			
174	3/25/09	10:00	3/25/09 10:00	1.0063	-2			
175	3/25/09	12:00	3/25/09 12:00	0.9734	-2			
176	3/25/09	14:00	3/25/09 14:00	0.9345	-2			
177	3/25/09	16:00	3/25/09 16:00	0.8925	-2			
178	3/25/09	18:00	3/25/09 18:00	0.8520	-2			
179	3/25/09	20:00	3/25/09 20:00	0.8116	-2			
180	3/25/09	22:00	3/25/09 22:00	0.7610	-2			
181	3/26/09	0:00	3/26/09 0:00	0.7207	-2			
182	3/26/09	2:00	3/26/09 2:00	0.6796	-2			
183	3/26/09	4:00	3/26/09 4:00	0.6289	-2			
184	3/26/09	6:00	3/26/09 6:00	0.5914	-2			

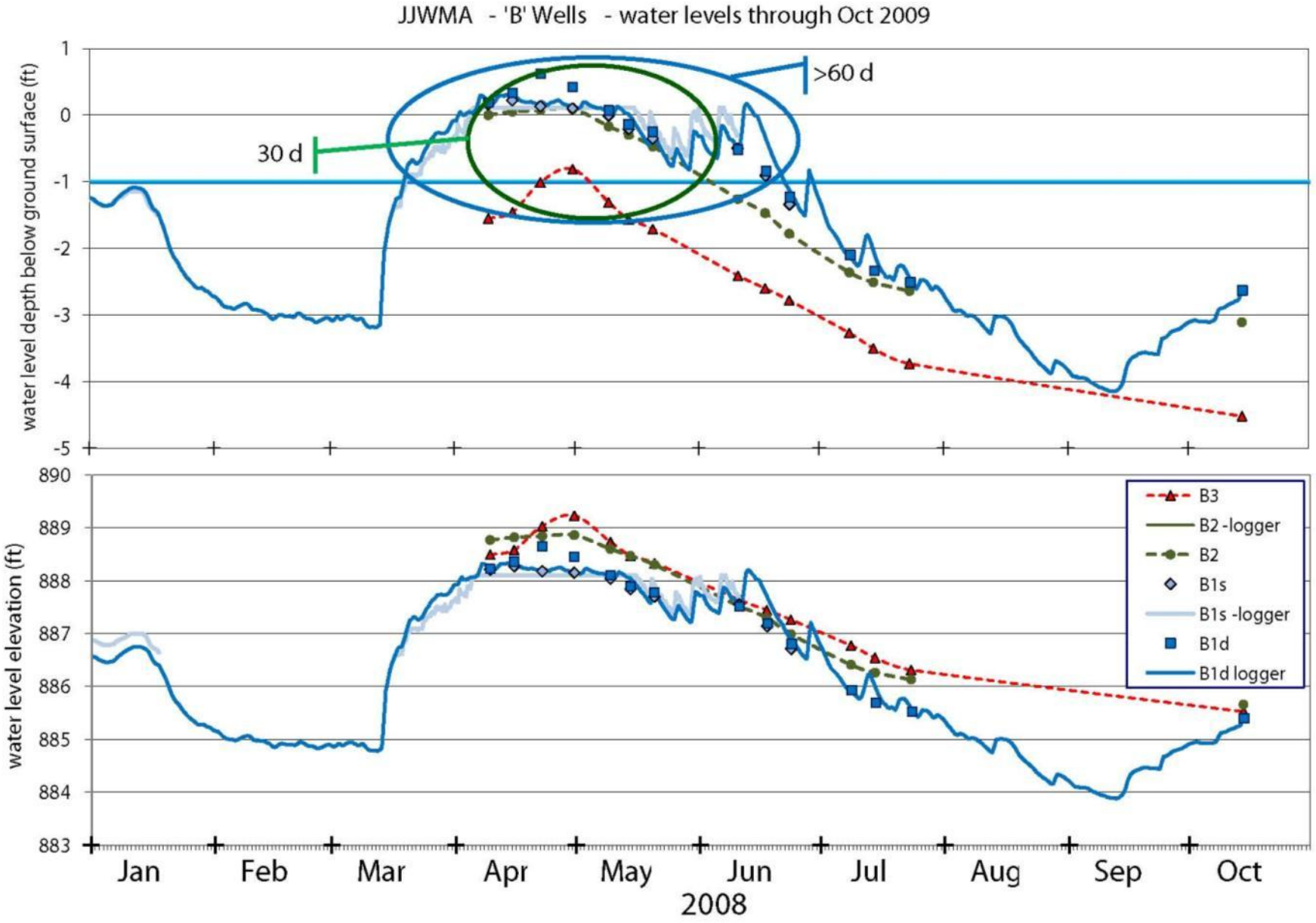
A1s A1d A2s A2d A3 B1 B2

Ready

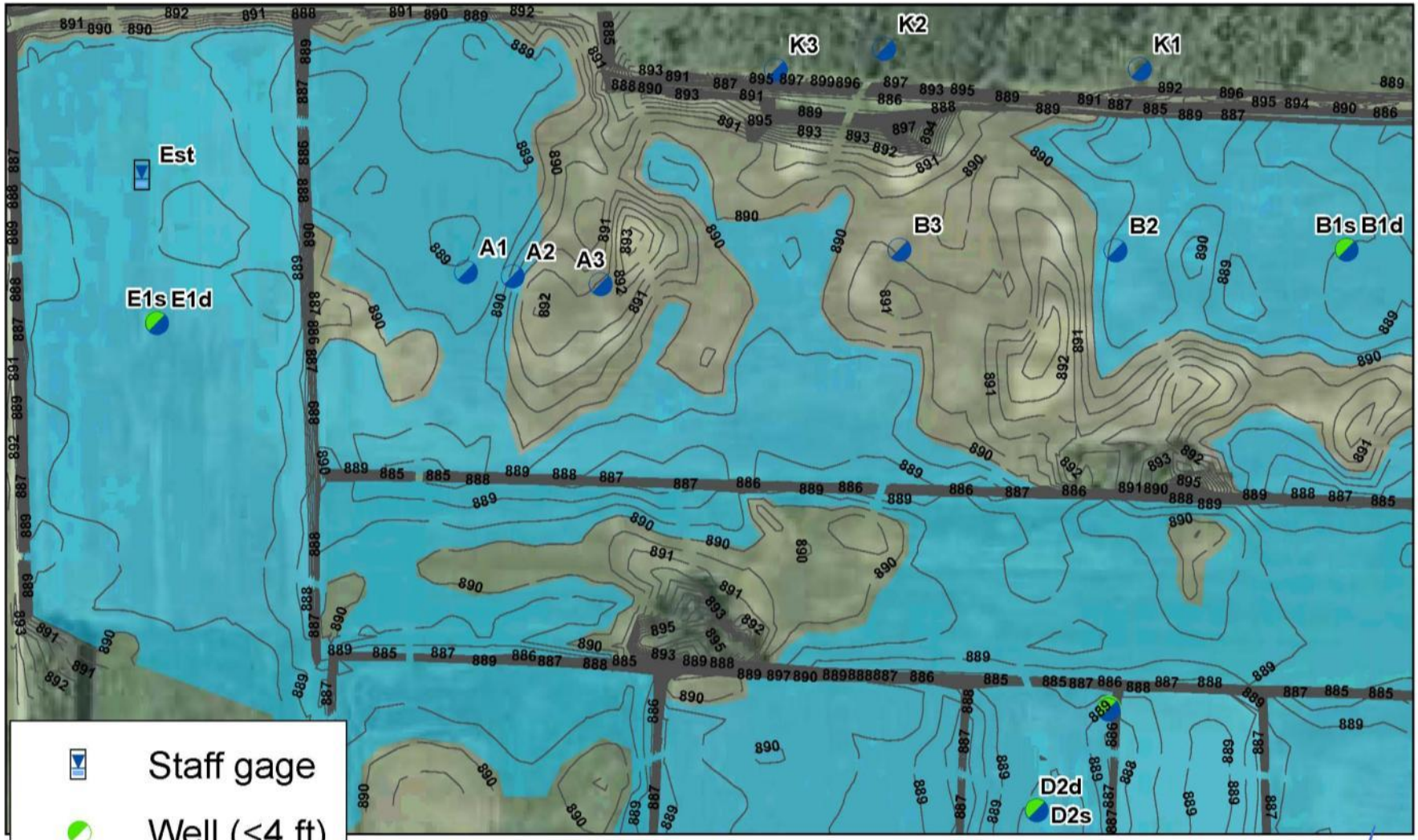
	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	#		WL-1W (peat well) or direct surface water measurement			WL-1P (#1 piezometer)			WL-2P (#2 piezometer)			WL-3P (#3 piezometer)		
2	depth bls		3.9			8.02			8.3			15.11		
3	toc elev		95.17			94.57			96.15			100.93		
4	stickup		1.80			1.35			1.10			1.35		
5	date	year	btoc	elev	bls	btoc	elev	bls	btoc	elev	bls	btoc	elev	bls
22	03-Apr-98	1998.26	0.66	94.51	1.14	0.28	94.29	1.07	2	94.15	-0.9	6.8	94.13	-5.45
23	13-May-98	1998.37	0.88	94.29	0.92	0.41	94.16	0.94	1.82	94.33	-0.72	6.69	94.24	-5.34
24	06-Jul-98	1998.52	0.7	94.47	1.1	0.22	94.35	1.13	1.59	94.56	-0.49	6.37	94.56	-5.02
25	14-Jul-98	1998.54	0.69	94.48	1.11	0.22	94.35	1.13	1.73	94.42	-0.63	6.55	94.38	-5.2
26	15-Jul-98	1998.54							1.76	94.39	-0.66	6.58	94.35	-5.23
27	07-Apr-99	1999.27	1.02	94.15	0.78	0.60	93.97	0.75	2.45	93.7	-1.35	7.3	93.63	-5.95
28	03-Aug-99	1999.59	0.8	94.37	1	0.40	94.17	0.95	1.85	94.3	-0.75	6.7	94.23	-5.35
29	05-Jul-00	2000.51	1.14	94.03	0.66	0.54	94.03	0.81	2.16	93.99	-1.06	6.94	93.99	-5.59
30	22-Aug-00	2000.64	1.16	94.01	0.64	0.61	93.96	0.74	2.25	93.9	-1.15	7.02	93.91	-5.67
31	09-Oct-00	2000.77	1.46	93.71	0.34	0.95	93.62	0.4	2.58	93.57	-1.48	7.38	93.55	-6.03
32	14-May-01	2001.37	0.15	95.02	1.65	-0.44			1.04	95.11	0.06	5.78	95.15	-4.43
33	05-Jun-01	2001.43	0.12	95.05	1.68	-0.48			0.99	95.16	0.11	5.73	95.2	-4.38
34	10-Aug-01	2001.61	0.26	94.91	1.54	-0.35			1.15	95	-0.05	5.88	95.05	-4.53
35	12-Aug-01	2001.62							1.22	94.93	-0.12			
36	17-Jun-02	2002.46	1.09	94.08	0.71	0.47	94.10	0.88	2.16	93.99	-1.06	6.8	94.13	-5.45
37	29-Jul-02	2002.58	0.19	94.98	1.61				1	95.15	0.1	5.61	95.32	-4.26
38	29-Jul-02	2002.58							1.03	95.12	0.07	5.66	95.27	-4.31
39	03-Mar-03	2003.17							frozen			6.48	94.45	-5.13


Vivian Johnson Wetland Bank, Dodge County
Monitoring well water level data
2009 - all wells
Water level below ground surface (ft)
0.5
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
-4
-4.5
-5
-5.5
4/1
5/1
6/1
7/1
8/1
9/1
10/1
11/1
C2s
C1d
B2
A1s
A2s
B4s
A3
A1d
C1d
A3
D1
A1s
A1d
A2s
A2d
A3
B1
B2
B3
B4s
B5
C1d
C2s
C2d
C3
D1
E1
E2


Vivian Johnson Wetland Bank, Dodge County
Monitoring well water level data
2009 - all wells
Water level below ground surface (ft)
0.5
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
-4
-4.5
-5
-5.5
C2s
C1d
B2
A1s
A2s
B4s
A3
A1d
C1d
D1
A3
A1s
A1d
A2s
A2d
A3
B1
B2
B3
B4s
B5
C1d
C2s
C2d
C3
D1
E1
E2
4/1
5/1
6/1
7/1
8/1
9/1
10/1
11/1
daily precipitation (in)
30% (dry)
monthly precipitation (in)
30-d rolling sum
70% (wet)
Vivian Johnson Wetland Bank
2009 Precipitation analysis
precipitation (in)
8
7
6
5
4
3
2
1
0
4/1
5/1
6/1
7/1
8/1
9/1
10/1
11/1
2009 date


JJWMA - 'B' Wells - water levels through Oct 2009
water level depth below ground surface (ft)
1
0
-1
-2
-3
-4
-5
>60 d
30 d
water level elevation (ft)
890
889
888
887
886
885
884
883
B3
B2 -logger
B2
B1s
B1s -logger
B1d
B1d logger
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
2008

JJWMA 2008 Hydrologic Monitoring



Monitoring Wetland Hydrology

- **Planning**
  - Agree on objective, question to answer.
  - Use appropriate method.
  - Use professional judgment, landscape, topography.
- **Documentation**
  - Locations, construction details
- **Maintenance**
  - Check elevations, function

Eric Mohring
eric.mohring@state.mn.us
651-297-7360